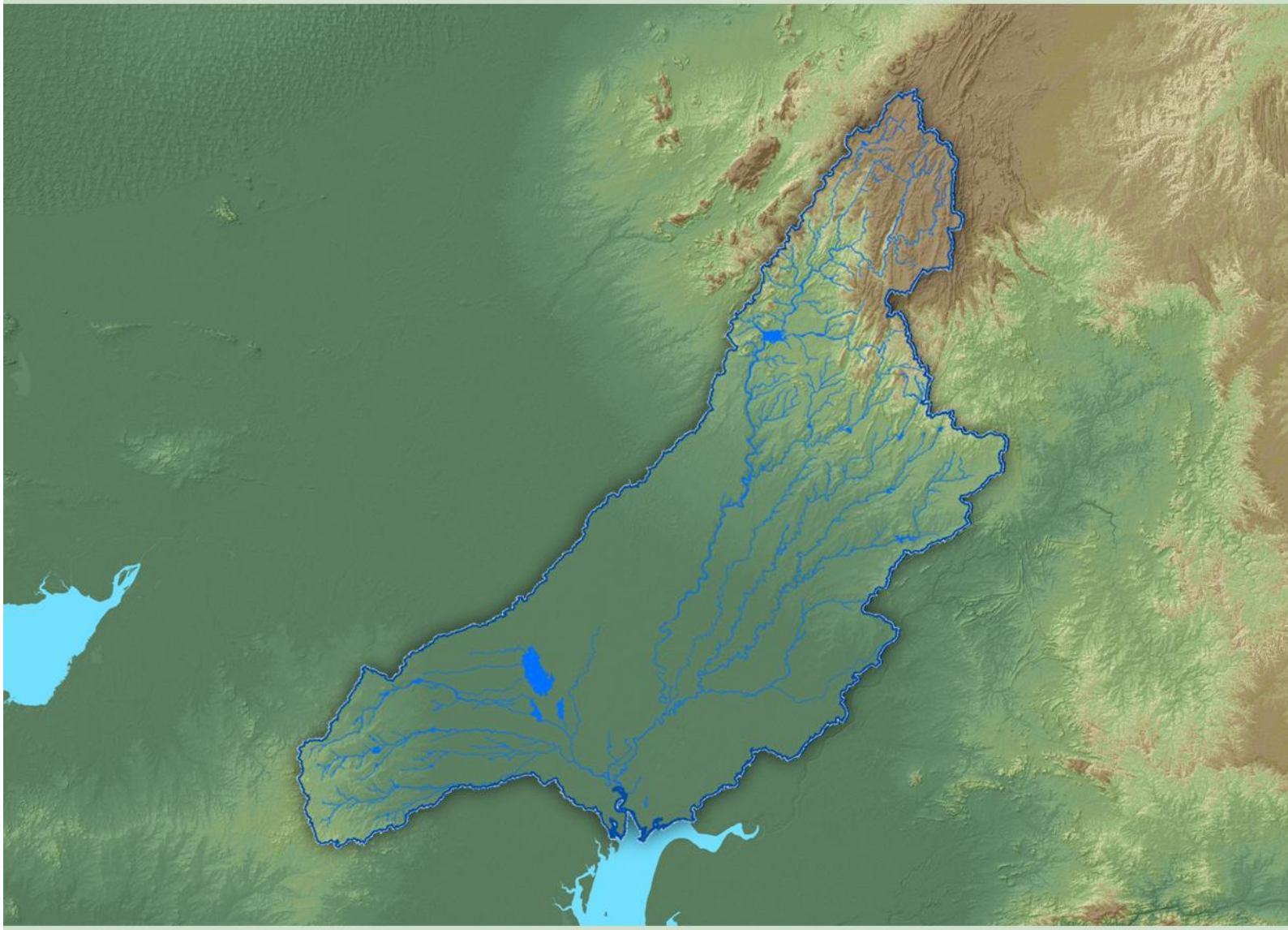
Version 2.0

Government of India
Ministry of Water Resources

SABARMATI BASIN



March, 2014

Central Water Commission
Ministry of Water Resources
Sewa Bhawan, R.K. Puram
New Delhi – 110 066

National Remote Sensing Centre (NRSC)
ISRO, Department of Space
Govt. of India, Balanagar
Hyderabad – 500 037

Preface

Optimal management of water resources is the necessity of time in the wake of development and growing need of population of India. The National Water Policy of India (2002) recognizes that development and management of water resources need to be governed by national perspectives in order to develop and conserve the scarce water resources in an integrated and environmentally sound basis. The policy emphasizes the need for effective management of water resources by intensifying research efforts in use of remote sensing technology and developing an information system. In this reference a Memorandum of Understanding (MoU) was signed on December 3, 2008 between the Central Water Commission (CWC) and National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO) to execute the project "Generation of Database and Implementation of Web enabled Water resources Information System in the Country" short named as India-WRIS WebGIS.

India-WRIS WebGIS has been developed and is in public domain since December 2010 (www.india-wris.nrsc.gov.in). It provides a 'Single Window solution' for all water resources data and information in a standardized national GIS framework and allow users to search, access, visualize, understand and analyze comprehensive and contextual water resources data and information for planning, development and Integrated Water Resources Management (IWRM).

Basin is recognized as the ideal and practical unit of water resources management because it allows the holistic understanding of upstream-downstream hydrological interactions and solutions for management for all competing sectors of water demand. The practice of basin planning has developed due to the changing demands on river systems and the changing conditions of rivers by human interventions. The multiple uses of water and varying demands on a river basin require an integrated approach to managing river basin.

Basin wise report generation is one the important deliverables of India-WRIS project. Report of Sabarmati basin describes systematically the present status of water resources: major water resources projects, hydro-meteorological observations, surface and ground water development scenario, topographic characteristics, climatic variability, land use / land cover pattern & allied natural resources along with socio-economic profile of the basin. The report contains valuable latest information of the basin on all aspects of water resources and allied sectors and will be useful as baseline information for the irrigation officials, hydrologists, agriculturalists, conservationists, research organizations and all those involved in the development of Sabarmati basin.

Acknowledgements

The Sabarmati basin report is an outcome of the project "Generation of Database and Implementation of Web enabled Water resources Information System in the Country" short named as India-WRIS WebGIS jointly executed by the Central Water Commission (CWC) and National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO). This comprehensive publication gives the present status of water resources assets, topographic features, climatic variability, land use / land cover pattern & allied natural resources along with socio-economic information of the basin.

We, on behalf of the authors and India-WRIS project team acknowledge; Shri Alok Rawat, Secretary, Ministry of Water Resources; Mrs. Sudha Midha, Additional Secretary, Ministry of Water Resources; Er. A. B. Pandya, Chairman, Central Water Commission; Dr. K. Radhakrishnan, Chairman, Indian Space Research Organization and Secretary, Department of Space; Shri Sudarsanam Srinivasan, Secretary to GOI and Member- Finance, Department of Space; Shri A. Vijay Anand, Additional Secretary, Department of Space; Dr. V. Koteswara Rao, Scientific Secretary, ISRO; Dr. V. Jayaraman, Ex-Director, NRSC for constant encouragement and guidance, technical discussions and for evincing keen interest in India-WRIS project and this report.

Our foremost acknowledgement is towards India-WRIS project team who created and organized large number of data sets and information in GIS format as seamless layers and attribute data for the entire country which served as base for this report. Thanks are also due to all CWC and NRSC / ISRO officials who carried out the quality assurance and shown their enthusiastic involvement. Finally, our sincere thanks are to all divisions and officials of NRSC and CWC for their valuable support during the preparation of this report.

The basin report includes the results generated through interpretation of latest satellite imageries as well as compilation of huge information from voluminous records. This would not have been possible without the countrywide support. We would like to thank all the organizations, institutes and individuals who contributed either directly or indirectly in bringing out this publication.

Dr. J R Sharma
Project Director, India-WRIS &
Chief General Manager, RCs/ NRSC/ ISRO, New Delhi

Er. Yogesh Paithankar
Project In-charge, India-WRIS &
Director, CWC, New Delhi

Executive summary

This report provides valuable information related to the topographic, demographic, climatic, surface and Ground water resources, hydro meteorological and water quality scenario of Sabarmati basin. The basin is comprised of two sub-basins; 1. *Sabarmati Upper Sub Basin* (64.58% of total basin area) consisting of 34 watersheds. 2. *Sabarmati Lower Sub Basin* (35.42% of total basin area) consisting of 17 watersheds. The Sabarmati and its tributaries are an inter-state river system flowing through the states of Gujarat and Rajasthan. This river comprised of major tributaries on both the banks viz. Wakal, Hathmati, Watrak and Sei.

The basin falls into two Agro-Climatic Zones and three Agro-Ecological Zones. As per the assessment of LULC (2005-06), a large part (74.68%) of the basin is covered with agricultural land. Forest area spread over 11.98% and waterbodies occupy 4.19% of the total basin area. Black, alluvial and sandy soils are predominant in the basin but red and yellow soils are also found at few places. Major part of the basin area lies in the elevation zone of 10-200 m. As per 2001 census, the total population within the basin is about 13,307,250and spread in 15 districts.

The Average annual rainfall of the Sabarmati basin (during 1971-2004) is 689.90 mm. The average annual mean temperature for this period is 26.33°C. Generally the Waterbodies in the basin are utilized for irrigation, fisheries and water supply. In the basin, there are 3247Waterbodies, which include lakes/ponds, tanks, aquaculture pond, reservoir, ox-bow lake and cooling pond. Majority of the surface waterbodies are tanks (91.62%) and lakes/pond (5.97%). Nearly 50 dams, 2 barrages and 10 weirs are also constructed in the basin. Around 91.67% dams are used for the purpose of irrigation.

There are three AIBP projects in Sabarmati basin. A large network of canals have been constructed over these projects. There are 18 completed and 2 ongoing major/medium irrigation, 2 multi-purpose irrigation projects and 1 interstate projects in Sabarmati basin. The important projects in the basin constructed during plan period are Sardar Sarovar Major Irrigation Project (Gujarat), Mahi Stage-I (Wanakbori) Major Irrigation Project, Motifatewadi Major Irrigation Project, Sabarmati (Dharoi) Major Irrigation Project, Sei Medium Irrigation Project, Watrak Major Irrigation Project, Hathmati Major Irrigation Project, Meshwa Major Irrigation Project, Kharicut Canals Major Irrigation Project and Meshwo Canal Major Irrigation Project.

There are 15 hydro-meteorological and 2 flood forecasting stations of Central Water Commission are located in the basin. Apart from these 21 IMD stations and 10 AWS stations are also functional.

Surface water quality observations are taken at 3 sites of CWC located in Gujarat. 243 well locations in the Sabarmati basin measures Ground water quality parameters.

Rajasthan-Sabarmati link canal is an extension of the proposed Yamuna-Rajasthan Link. The link envisages a transfer of 5,924 mm^3 water available at the tail end of the Yamuna-Rajasthan link for drought prone areas of Rajasthan and Gujarat.

There are 11 water tourism sites are located in the basin, includes National parks, Pilgrimages and waterfalls.

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1. Introduction

1.1 Overview of basin

River basins form the basic hydrological units for water resources planning. The basin has been recognized as a practical hydrological unit for water resources management. In fact, optimal development of the water resources can't possibly be achieved unless individual water resources development projects are considered as a part of the basin level plan.

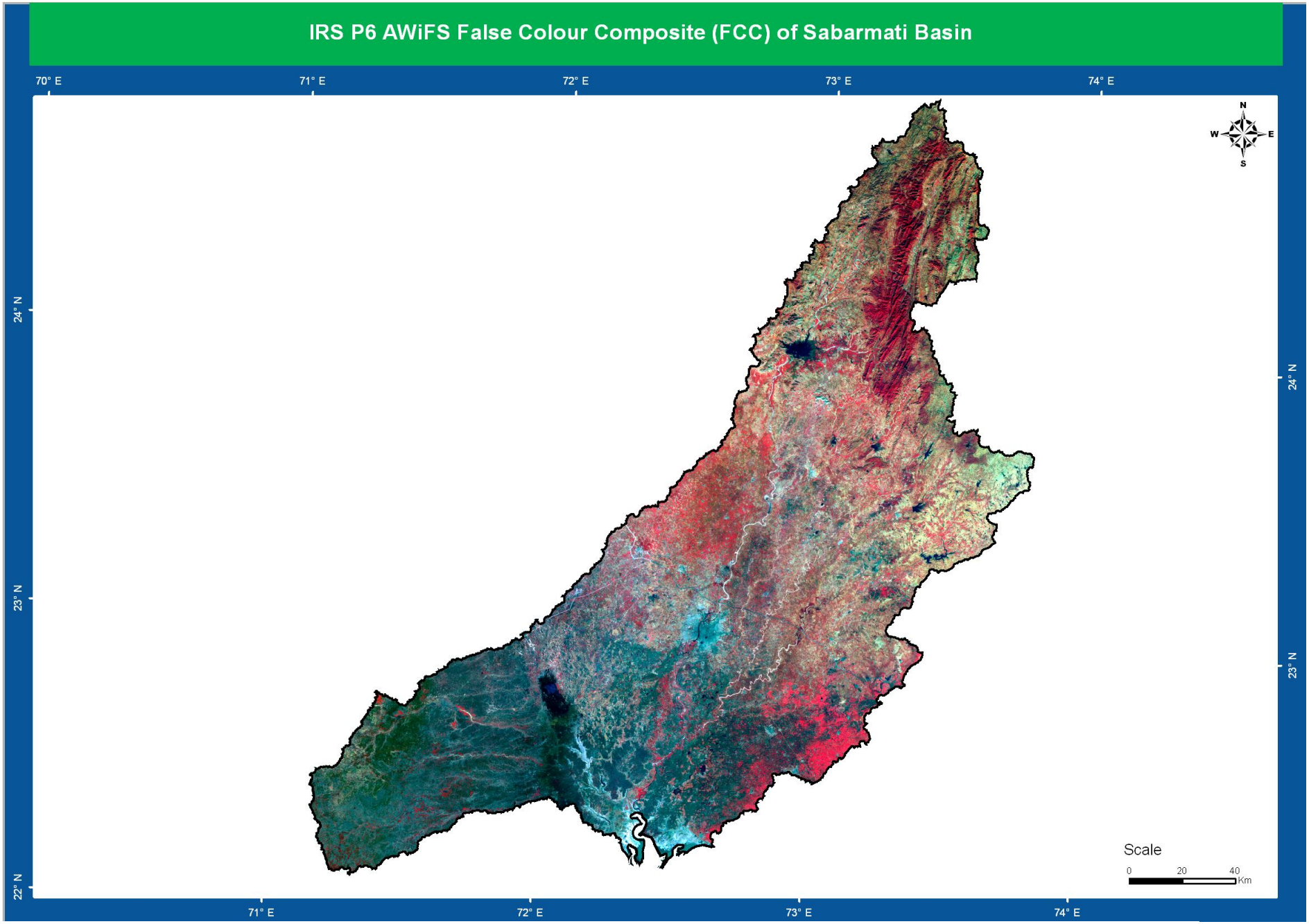
Sabarmati River is one of the major west flowing rivers of India. The Sabarmati basin extends over the states of Rajasthan and Gujarat having an area of 21,674 Sq. km with maximum length and width of 300 km and 150 km respectively. It lies between 70°58' to 73°51' east and 22°15' to 24°47' north. The basin is bounded by Aravalli hills in the north and north-east, Rann of Kutch in the west and Gulf of Khambhat in the south. The Sabarmati basin extends over parts of Udaipur, Sirohi, Pali and Dungarpur districts of Rajasthan, Sabarkantha, Kheda, Ahmedabad, Mahesana, Gandhinagar and Banaskantha districts of Gujarat. The basin spreads over 15 parliamentary constituencies (2009) and is comprised 13 in Gujarat and 2 in Rajasthan. In Gujarat, the basin occupies an area of 17,550 Sq. km accounting to 81% of the total basin area. In Rajasthan, It covers an area of 4,124 Sq. km which accounts for 19% of the total basin area (Figure 1). The basin area contributed by different states is given in figure 1.

As far as water resources are concerned, the average annual runoff and average annual water potential of the basin is 3.81 BCM. The utilizable surface water in the basin accounts to 1.9 BCM.

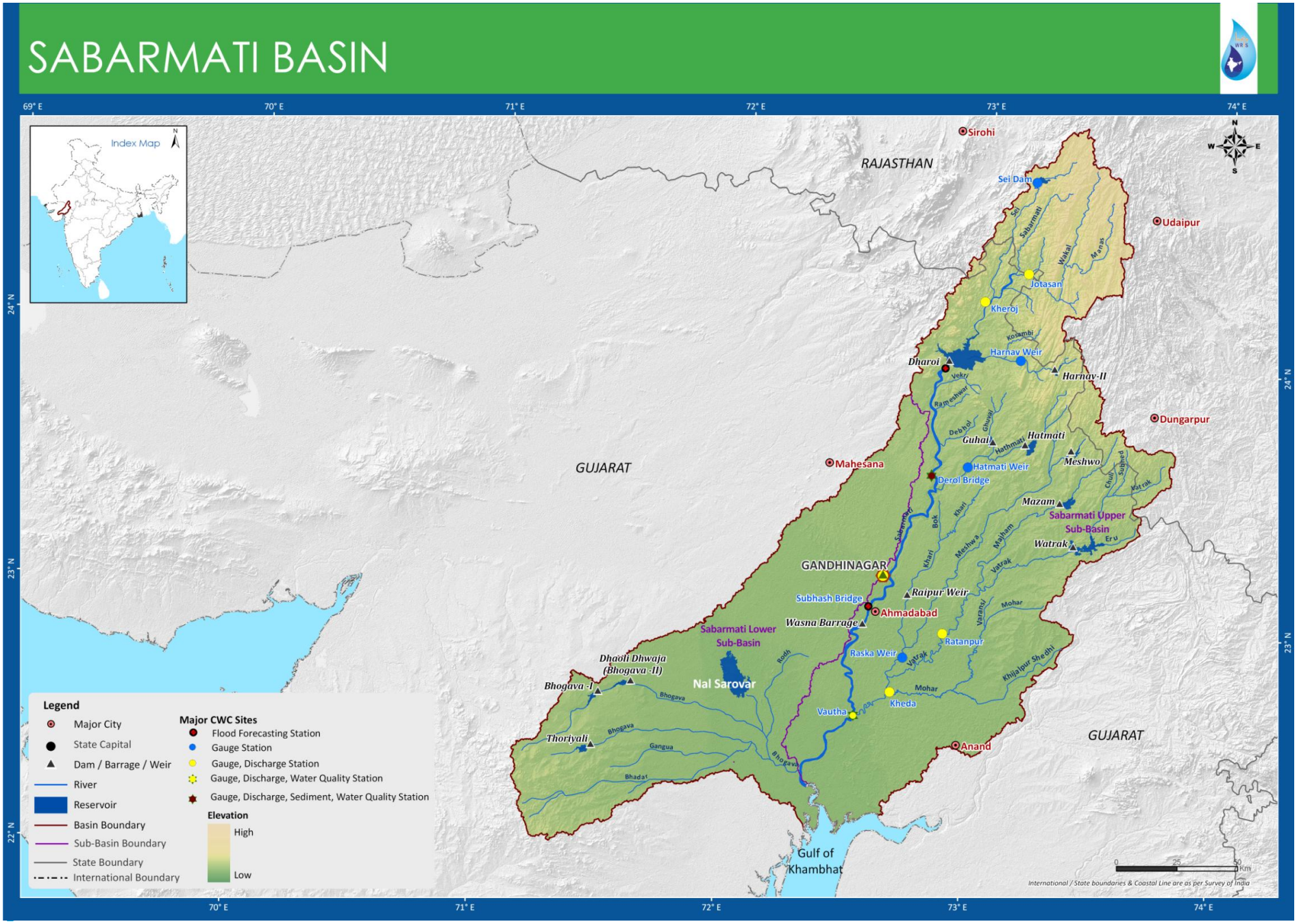
The basin is divided into 2 sub-basins *viz. Sabarmati Upper* and *Sabarmati Lower Sub-Basin*. They have been further clustered into 51 watersheds each of which represents a different tributary system. The Sabarmati and its tributaries are an interstate river system, flowing through the states of Rajasthan and Gujarat. The drainage network of Sabarmati River consists of 5 major tributaries. The basin is roughly triangular in shape with the Sabarmati River as the base and the source of the Watrak River as the apex point. Sabarmati originates from Aravalli hills at an elevation of 762 m near village Tepur in Udaipur district of Rajasthan. The total length of river from origin to outfall into the Arabian Sea is 371 km and its principal tributaries joining from left are Wakal, Hathmati and Watrak whereas Sei joins the river from right.

The total population in the basin is 1,33,07,250. Out of this, 69,48,046 (52.21%) are males and 63,59,204 (47.78 %) are females. The basin has 4,720 villages and 30,69,264 households. Map 1 shows the geographical location of the basin with terrain features from DEM. The highlighted blue boundary shows the basin extent overlaid on state boundary. Map 3 gives a detailed view of the basin where the drainage network and its pattern across the basin is also shown. Major hydro meteorological stations and flood forecasting sites are also shown in the map. Table 1 gives a glance at the salient features of the basin.

Map 1. Index map



Map 2. Satellite Imagery



Map 3. Sabarmati basin- drainage and sub-basin

Table 1. Salient features of Sabarmati basin

Sl. No.	Features	Description
1	Basin Extent	70° 58’ to 73° 51' E 22° 15’ to 24° 47’ N
2	Area (Sq.km)	21,674*
3	States in the basin	Gujarat (87.15 %), Rajasthan (12.85 %)
4	Districts (Census 2011)	15
5	Parliamentary Constituencies (2009)	16
6	Mean Annual Rainfall (mm)	689.90
7	Mean Maximum Temperature (^{o}C)	39.33
8	Mean Minimum Temperature (^{o} C)	10.95
9	Total Population (Census 2011)	3,69,08,052
10	Number of villages	4,720
11	Highest Elevation (m)	1,173
12	Avg. Annual Water Potential (BCM)	3.81
13	Utilizable Surface Water (BCM)	1.90
14	Number of Sub-basins	2
15	Number of Watersheds	51
16	Number of water resources structures	Dams (50), Barrages (2) ,Weirs (10)
17	Highest Dam	Sabarmati Dam (46 m)
18	Longest Dam	Mulbavla Dam (9735 m)
19	Highest Barrage	Wasna Barrage (20.75 m)
20	Longest Barrage	Varanai Barrage (1544 m)
21	Number of Irrigation projects	Major: 9,Medium: 11, ERM:4
22	Number of Hydro - Electric projects	-
23	Number of Ground water observation wells	243
24	Number of Hydro-Observation Sites	15
25	Number of Flood Forecasting Sites	2
26	Water tourism sites	11

**GIS based calculated area : 30,680 Sq. km.*

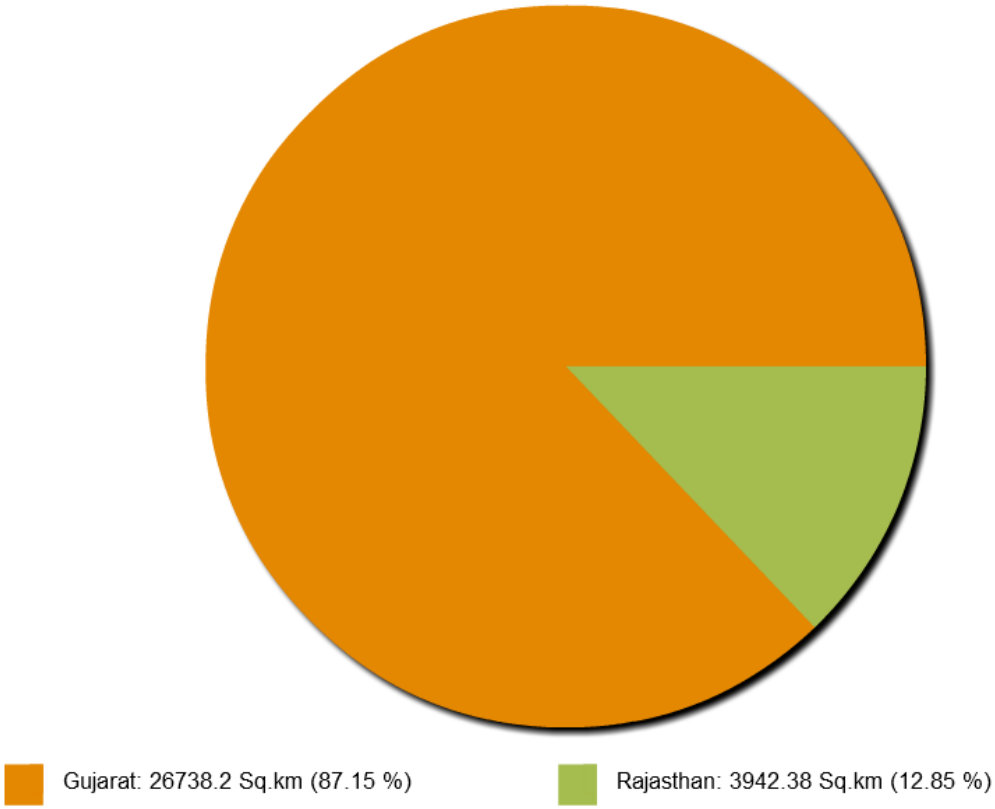


Figure 1. State wise basin area

1.2 Topography

The Sabarmati basin is bounded by Aravalli hills in the north and north-east, Rann of Kutch in the west and Gulf of Khambhat in the south. The basin has maximum length and width of about 300 km and 150 km, respectively. The terrain of Sabarmati basin is hilly in the early reaches up to Dharoi dam after which the river flows mostly in plains. The northern part of the basin is marked by hilly terrain while the southern part has large alluvium plain having gentle slope. The spatial variation of different elevation zones in the basin is depicted in Table 2.

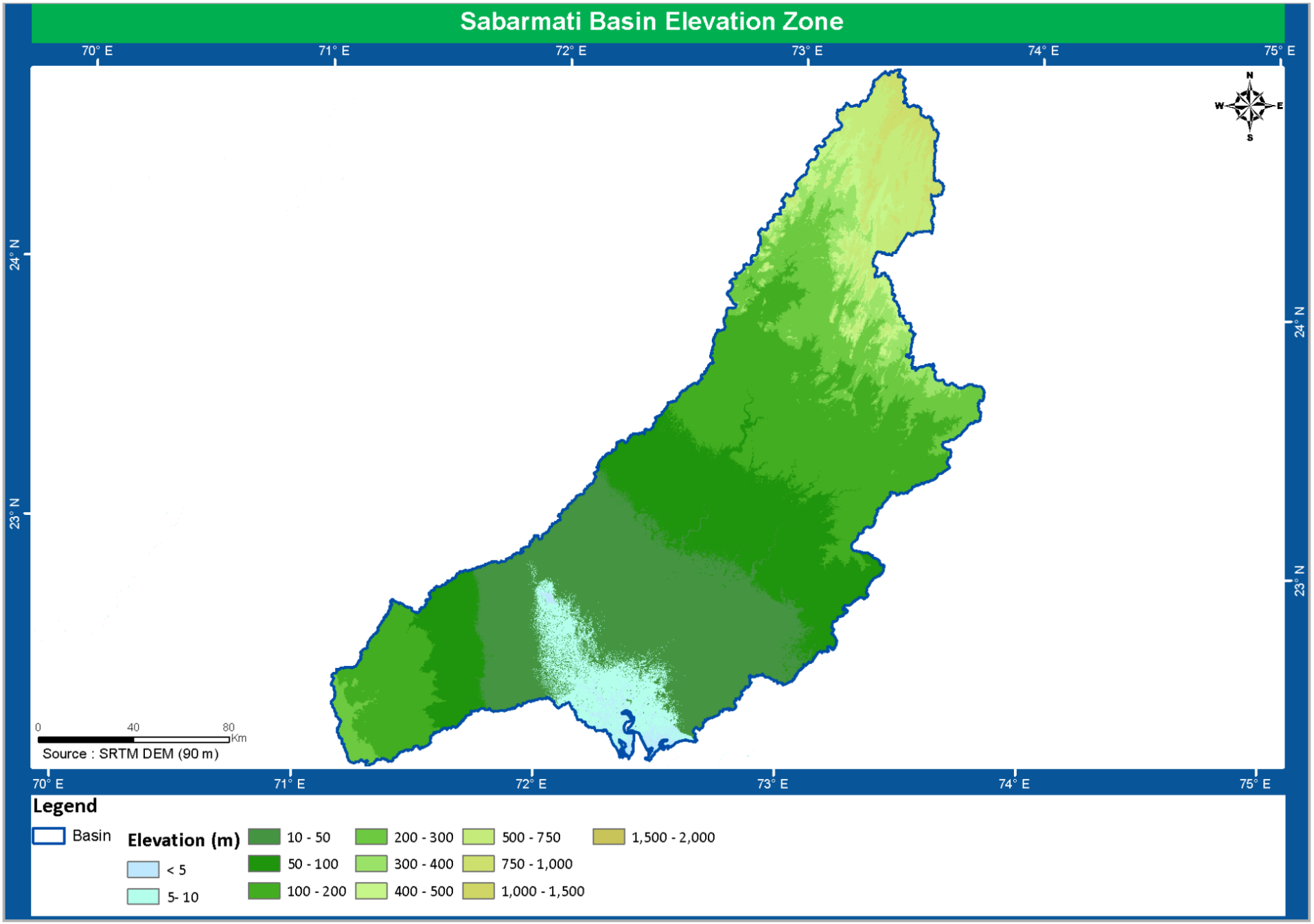
Height (Z) information of entire Sabarmati basin is derived from the Digital Elevation Model (DEM) data of Shuttle Radar Topography Mission (SRTM) with spatial resolution of 90 m. The highest elevation in the basin is 1,173 m. The elevation zone map of the basin is given in Map 4.

The basin is divided into 11 elevation zones based on SRTM DEM (Table 2). From DEM it is noted that major area of this basin falls under 10-50 m and 100-200 m elevation zones. Maximum elevation is observed in Ahmedabad and Kheda districts of Gujarat.

Table 2: Elevation zones

Sl. No.	Elevation (m)	Area (Sq.km)	% of Total Area
1	< 5	184.20	0.85
2	5-10	1113.85	5.14
3	10-50	5554.80	25.63
4	50-100	4303.09	19.85
5	100-200	5345.61	24.66
6	200-300	2063.20	9.52
7	300-400	883.49	4.08
8	400-500	612.57	2.83
9	500-750	1206.61	5.57
10	750-1000	396.40	1.83
11	1000-1500	10.18	0.05

**Note: Based on SRTM DEM*



Map 4. Elevation zones

1.3 Climate

Sabarmati basin experiences 3 marked seasons - Summer (March-May), Monsoon (June-September) and Winter (October-February). The winter season begins in December and continues till the end of February. January is the coldest month of the year. Clear bright weather, intersperse by brief spells of cloudy weather and accompanied by a little rain caused by western disturbances traversing north India is experienced during this part of the year. Winds blow mainly north-east.

From March onwards, the hot weather sets in and continues till the middle of June. Thunder-storms occur occasionally during this season. The winds are generally north-easterly. The south-west monsoon normally sets in by the middle of June and continues to be active till September. 95% of the annual rainfall occurs during this period. Heavy showers generally occur in association with monsoon depressions from the Bay of Bengal and the Arabian Sea. The south-west monsoon withdraws by about the middle of September and the weather clears up. Pleasant weather prevails till the end of December.

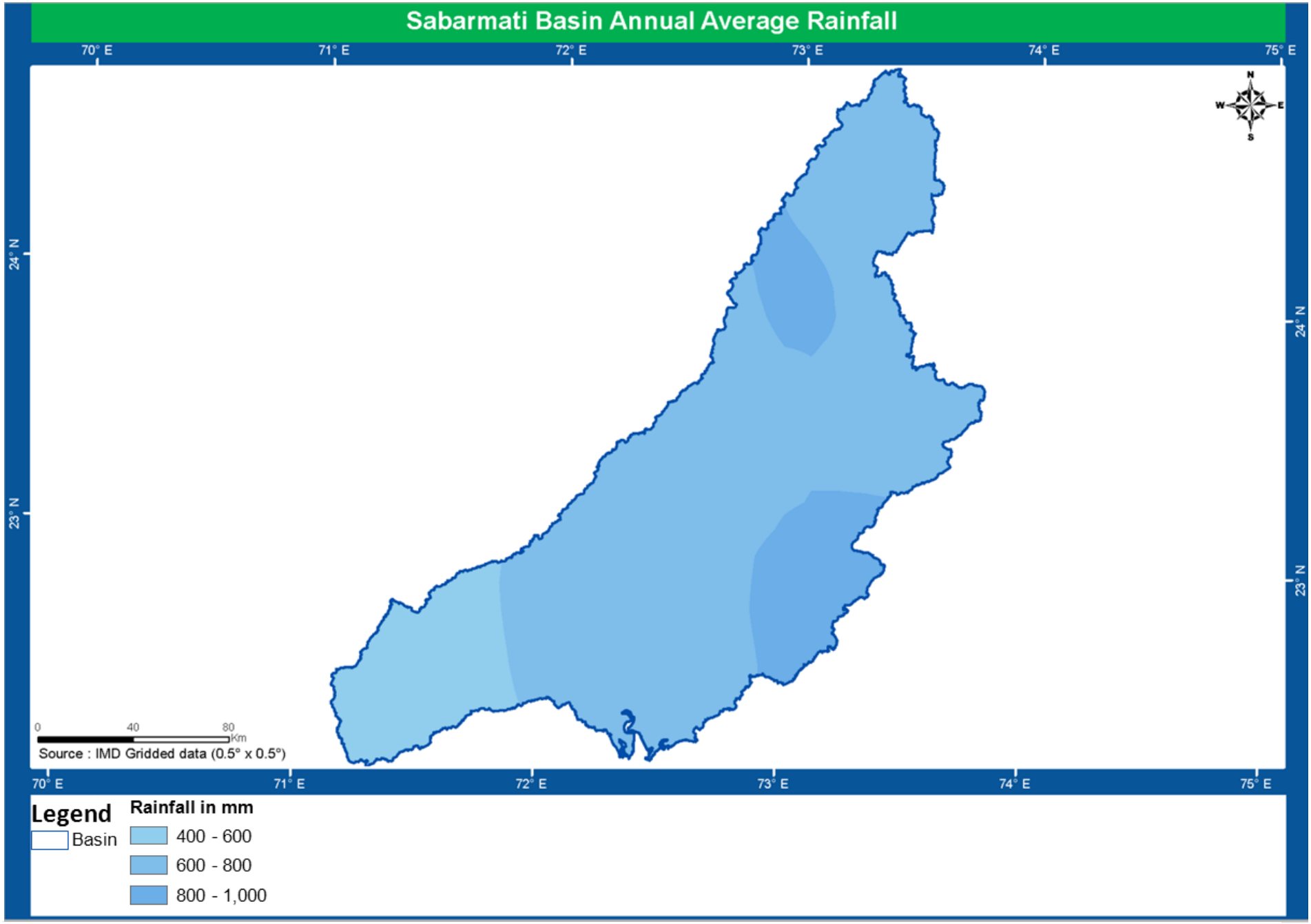
From the available data and record, the basin contains two climatic regions, the northern part of the basin comprises sub-tropical wet climate. The major part of basin comprises tropical wet climate causes mainly due to existence of Aravalli and the Western Ghats. The climate varies from arid in the Saurastra area to semi- arid in north Gujarat to humid in coastal areas.

(Source: Water Year Book, CWC, 2008-09)

1.3.1 Rainfall

The Average annual rainfall in the Sabarmati basin is 689.90 mm. The southwest monsoon sets in by middle of June and withdraws by the first week of October. The rainfall is mainly influenced by the southwest monsoon. The effect is most pronounced in Vadodara lying on the windward side of the Western Ghats. Monsoon contributes nearly 91-94% of annual precipitation. Average wind speed is the lowest in Udaipur and higher in Ahmedabad district. In general, wind speeds are taken to be moderate over most of the months.

Due to sparse rainfall and a momentary river system, the entire study area depends heavily on ground water for its domestic, agriculture and industrial requirements. An acute shortage of water is exacerbated by the inferior water quality in terms of salinity. Based on daily rainfall data (0.5^o X 0.5^o) for the period 1971-2004, collected from IMD, the average annual variations in the basin is shown in Map 5.The map shows that the spatial variation in rainfall is moderate. Major part of the basin area receives rainfall from 600-800 mm. A good network of hydrological and meteorological stations have been setup in the basin. At various locations wireless stations have been established to communicate the information about rainfall and discharge to a central control office where it is used to make decisions concerning regulation. The sub basin wise annual rainfall for 34 years is given in Annexure II: A.



Map 5. Annual Average Rainfall

1.3.2 Temperature

Daily temperature (maximum, minimum and mean) gridded data (1° x 1°) for 36 years (1969-2004) collected from IMD has been analyzed. Average monthly temperature variation for the 36 years (1969-2004) is given in Figure 2. Their parameters namely minimum, maximum and mean temperatures are given for comparison. In winter, the minimum temperature generally varies from 9°C to 14°C. However, temperatures have also been recorded in several areas. The maximum temperature in the basin varies from 39°C to 48°C. The temperatures average 11°C – 15°C in winters and as high as 38-47°C in summers. Month of May is generally the hottest month of the summer with mean maximum temperature of 34.4°C. January is the coldest month with mean minimum temperature of 18.76°C. The average annual minimum temperature (1969-2004) is 19.64°C. The average annual maximum temperature for the same period is 33.01°C. The average annual mean temperature for the period is 26.33°C. The higher elevations in the north experience lower temperatures.

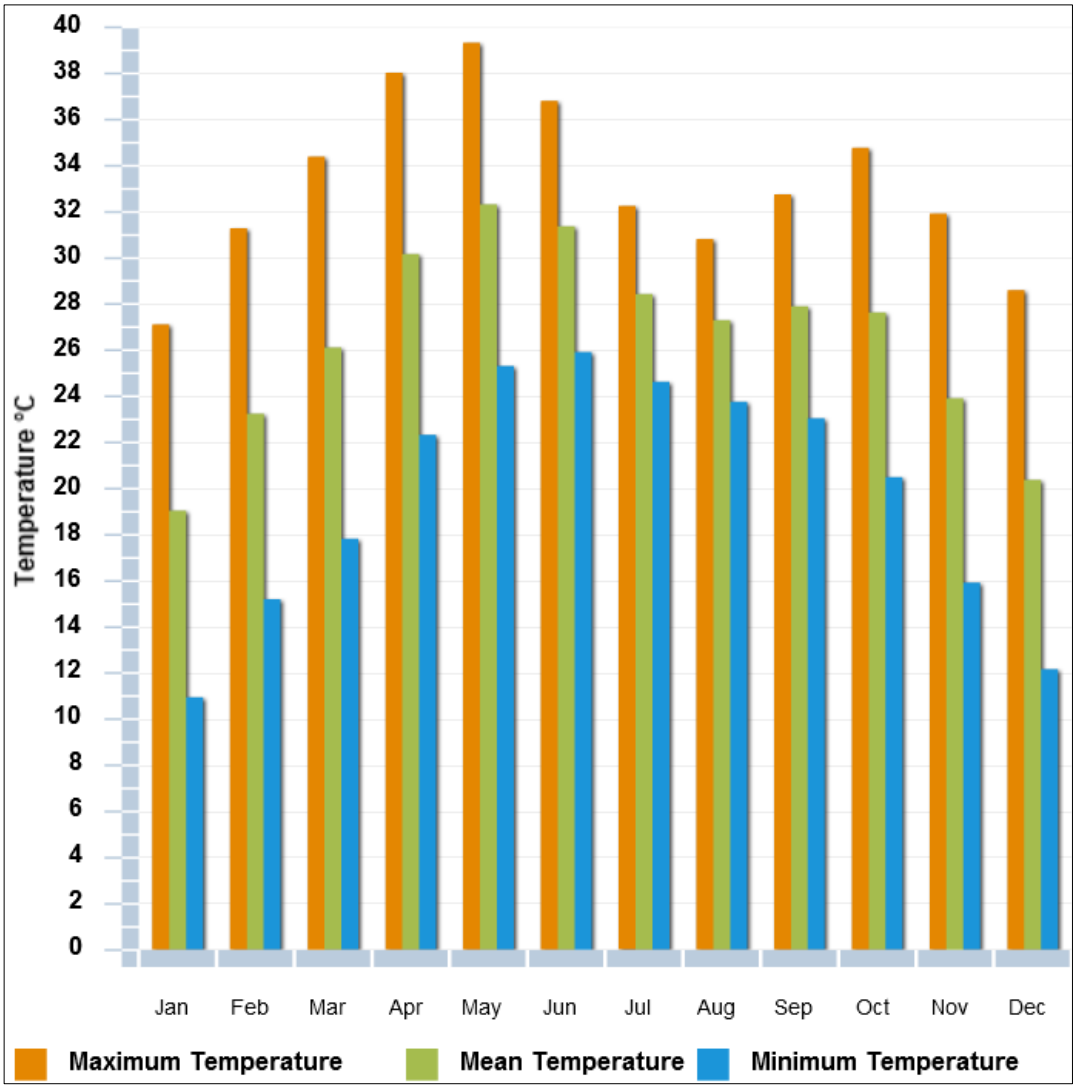


Figure 2. Monthly average temperature (1969-2004)

1.3.3 Trends and variability

The rainfall data in basin is based on the rainfall gridded daily data (0.5° x 0.5°) for 34 years (1971-2004) was interpolated to generate a raster layer. Trends have been generated based on area weighted average and regression analysis techniques. State, district, village and basin wise trends can be visualized monthly, seasonally and yearly.

In Sabarmati basin, the average annual rainfall varies at places. The highest rainfall of 1214.32 mm is observed in 1976 and lowest rainfall of 290.56 mm is observed in 1987. The rainfall trend graph shown in the Figure 3 indicates that there is a marginal decrease in average annual rainfall for 34 years (1971-2004). The average annual rainfall for the basin is estimated as 689.90 mm. During the monsoon months of June to September, the basin receives over 95% of the annual precipitation. *Details have been provided in Annexure: II A.* (Source: India-WRIS)

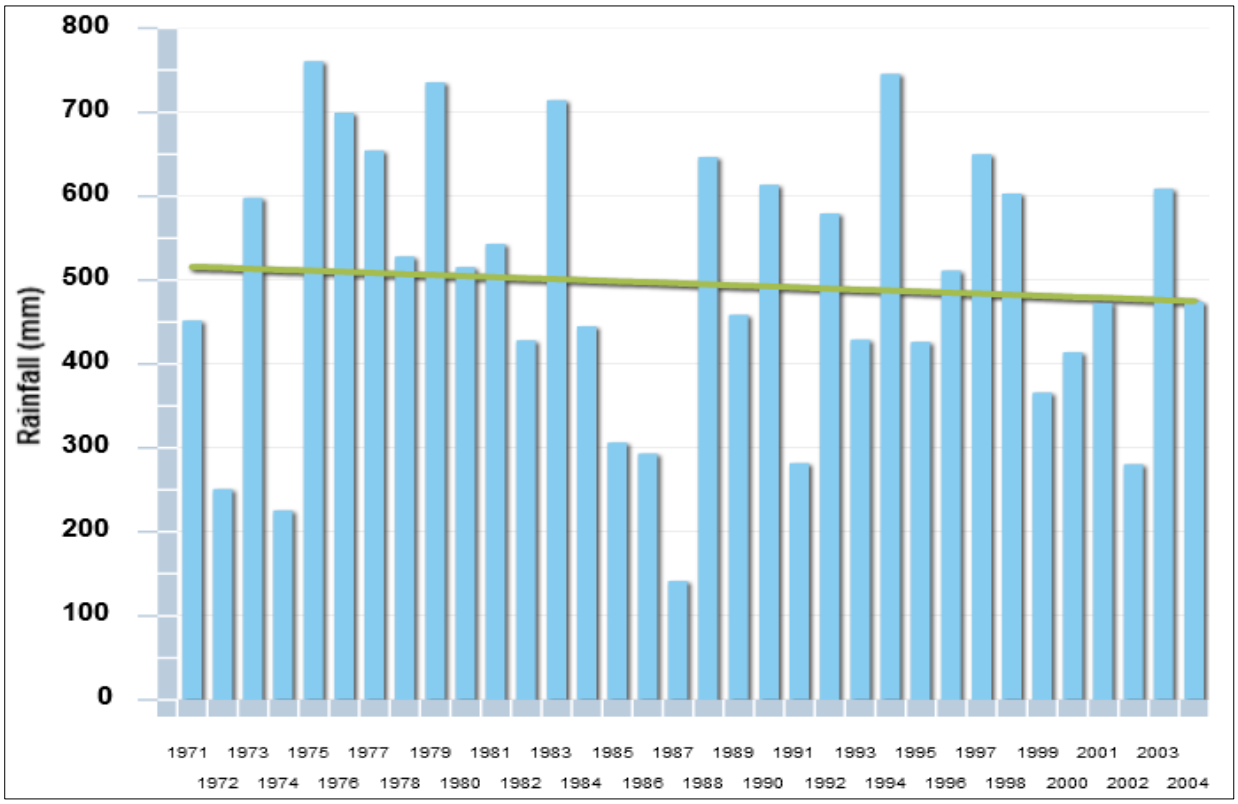


Figure 3. Trend of average rainfall (1971-2004)

1.4 Major rivers

River / Drainage constitutes of network, river / drainage channels which flow from higher reaches to lower levels often following the topography and slope of the terrain. They flow towards the sea or lake waters. The network of drainage constitutes a watershed or catchments. It consists of river and stream.

The Sabarmati River is one of the four main rivers which traverse the alluvial plains of Gujarat. It rises in the Aravalli hills at north latitude of 24° 40' and an east longitude of 73° 20' in the Rajasthan state at an elevation of 762 meters near the popular shrine of Amba Bhavani. After traversing a

course of about 48 km in Rajasthan, the river enters the Gujarat state. At the 51 km of its run, the Wakal river joins it from the left, near village Ghonpankhari. Flowing in a generally south-west and winding among jungle covered hills over a bed strewn with shingles and boulders, at the 67 km of its run, it receives the Sei River from the right near Mhauri and then the Harnav river the left at about 103 km from the source, before it enters Dharoi reservoir. Emerging from the dam it passes through the plains and is joined on its left at about 170 km from its source by the Hathmati river. Continuing to flow south-westwards, the river passes through Ahmedabad at about 165 km downstream of Dharoi dam. Further 65 km downstream, another tributary, the Watrak river joins it from the left. Flowing for a further distance of 68 km, the river outfalls into the Gulf of Cambay in the Arabian Sea.

The lengths of Sabarmati and its tributaries are summarized in Table 3. Description of some major tributaries of Sabarmati basin is given below:-

(a) Sei - This is a right bank tributary of Sabarmati River. It rises in the Aravalli hills in Rajasthan and flows in south-west direction for a total distance of 74.89 km before it joins Sabarmati on its right bank. It drains an area of 946 Sq. km.

(b) Wakal - This is a left bank tributary of Sabarmati River. It rises in the Aravalli hills in Rajasthan and flows in south-west direction for a total length of 88.54 km before it joins Sabarmati on its left bank. It drains an area of 1625 Sq km. Menas is its main tributary.

(c) Harnav - This is a left bank tributary of Sabarmati River. It rises in the northern portion of the Kulalia hills of Rajasthan and flows in south-west direction for a total distance of 59.07 km and joins the left bank of Sabarmati. It drains an area of 972 Sq. km.

(d) Hathmati - This is a left bank tributary of Sabarmati River. It rises in south-west foot hills of Rajasthan and Gujarat states and flows in south-west direction for a distance of 118.27 km to meet the Sabarmati on its left bank. Ghuvai and Boroli rivers are the sub-tributaries of Hathmati River. This tributary drains an area of 1526 Sq. km.

(e) Watrak - This is a left bank tributary of Sabarmati River. It rises in the Panchara hills in Dungarpur district of Rajasthan and flows in south-west direction for a distance of 231.69 km and joins Sabarmati on the left bank. Watrak and its tributaries drain an area of 8638 Sq. km.

Table 3. Length of major rivers (GIS Calculated)

Sl. No.	Tributaries/ River	Total Flowing length(km)
1	Sabarmati	352.235
2	Sei	74.89
3	Wakal	88.54
4	Harnav	59.07
5	Hathmati	118.27
6	Watrak	231.69
7	Dhamoi	49.70
8	Majam	96.509
9	Meswo	169.552

**Source: India-WRIS database*

1.5 Land use/land cover

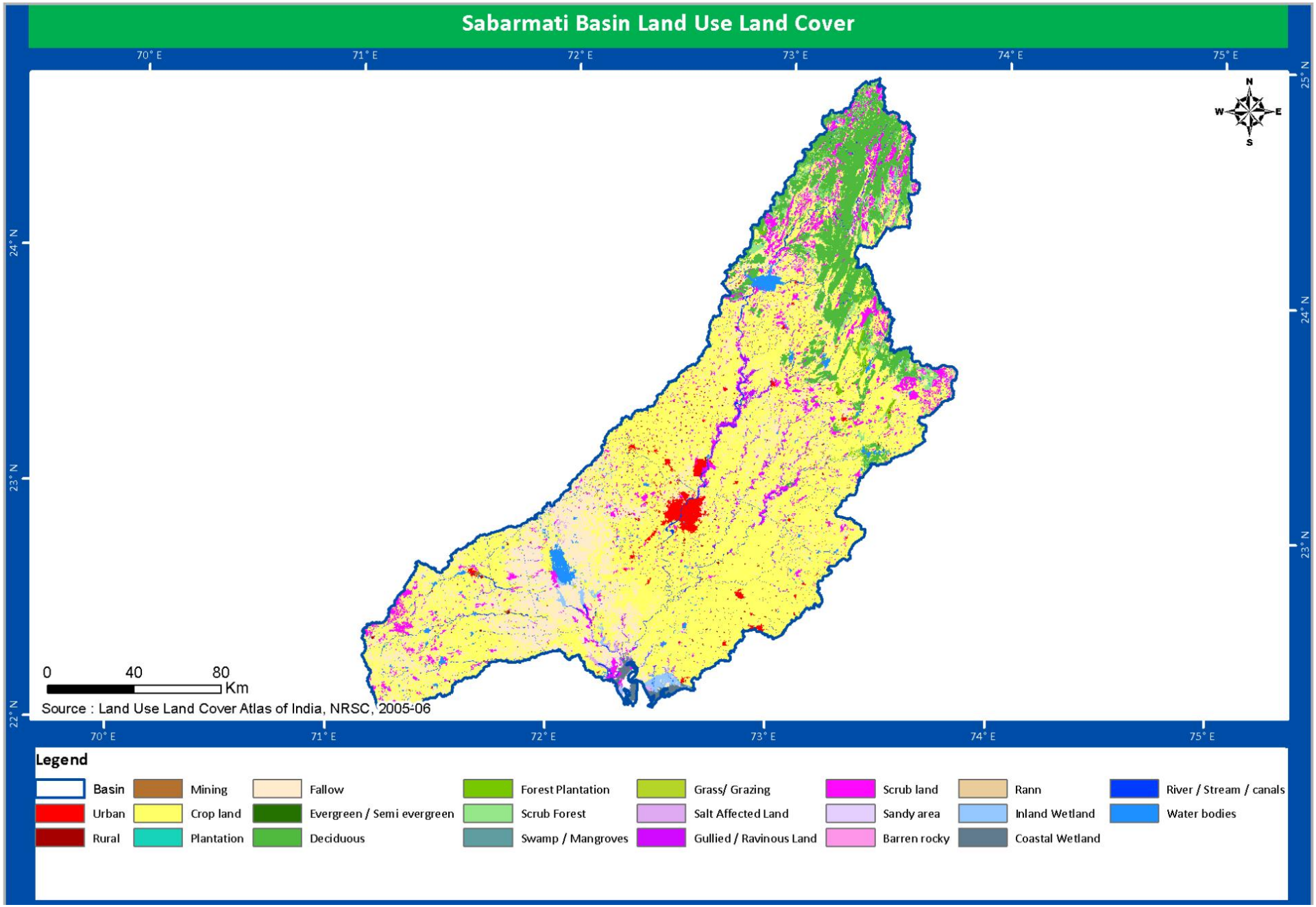
Land use is a description of how people utilize the land and socio-economic activity - Urban and agricultural land uses are the most commonly known land use classes. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension. Land cover is the physical material at the surface of the earth. Land cover include grass, asphalt, trees, bare ground, water, etc. This basin holds a variety of land cover and land use classes.

The distribution of land use/land cover units in Sabarmati basin during 2005-06 is given in Map 6. Major part of the basin is covered with agricultural land with an area of 16186.38 Sq. km (74.68% of the total geographical area). Sabarmati River and its tributaries have contributed to the land cover class Waterbodies by 4.19 %. The built up land (Includes Urban and Rural class) is 1.95% covering an area of 423.14 Sq. km. Forest cover in the basin is 2595.69 Sq. km which accounts for 11.98% of total area. Wasteland in the basin occupies 7.15%, covers an area of 1549.13 Sq. km (Table 4). Grassland accounts for 0.05% with an area of 10.72 Sq. km. The other main categories of land use/land cover in the basin are fallow land, scrub land, scrub forest, river/stream/canal, rural, urban mining, swamp/mangrove, etc.

The dominant crops harvested in the basin depend largely on the season and availability of water. The monsoon is the main cultivation season. Major crops grown during the kharif are bajra (pearl millet), cotton, groundnut, jowar, rice, and maize, while minor crops consist of pulses, millets, and tobacco. During the Rabi season (winter), wheat is the dominant crop. In some areas, crops are also grown during the hot summer season, but this depends entirely on the availability of irrigation water. The main crop during this growing season is bajra.

Table 4. Land use/ land cover statistics (2005-06)

S. No.	Category	Area (Sq. km)	% of Total Area
1	Built Up land	423.14	1.95
2	Agricultural	16186.38	74.68
3	Forest	2595.69	11.98
4	Grassland	10.72	0.05
5	Wasteland	1549.13	7.15
6	Waterbodies	908.94	4.19



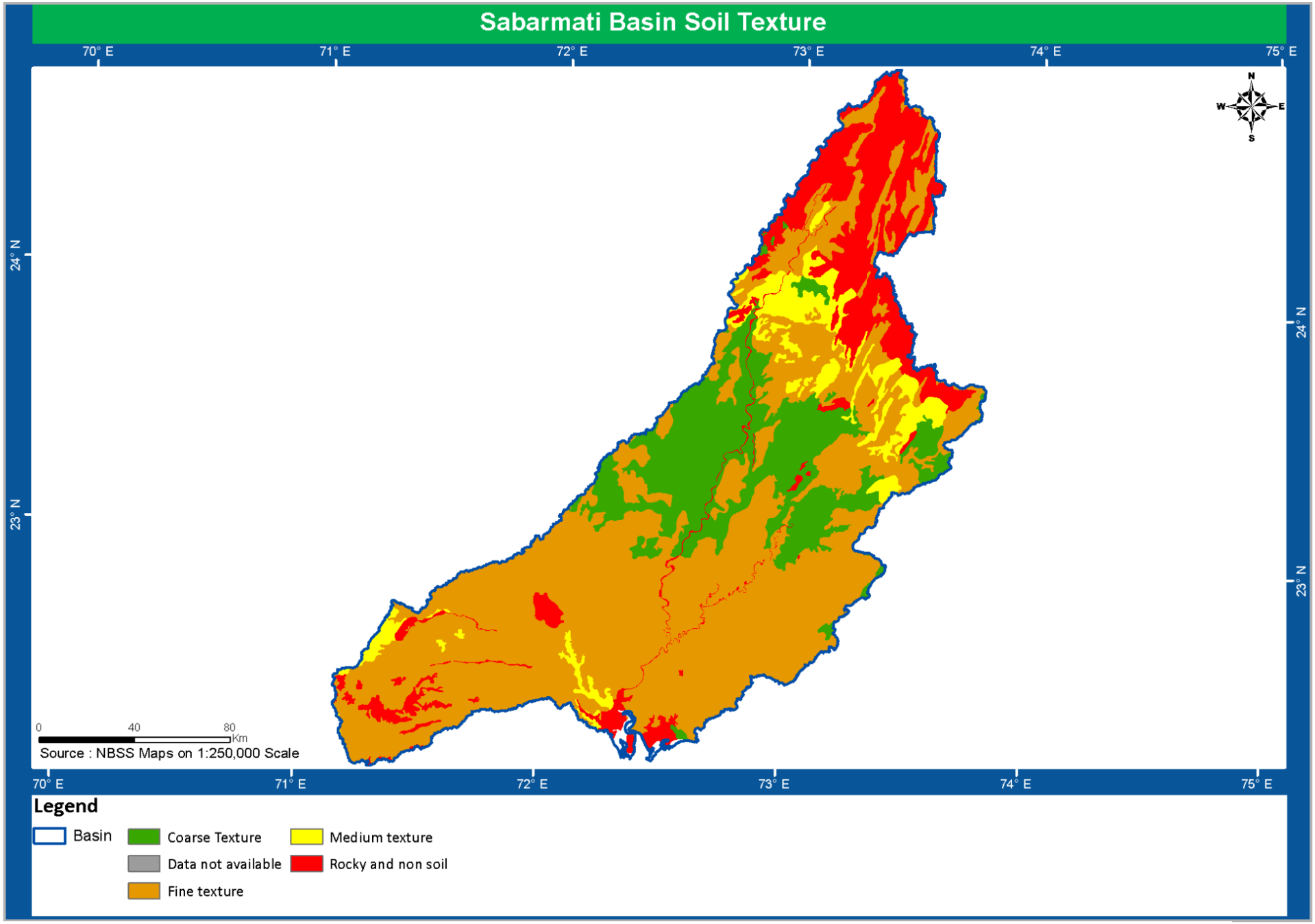
Map 6. Land use/land cover(2005-06)

1.6 Soils

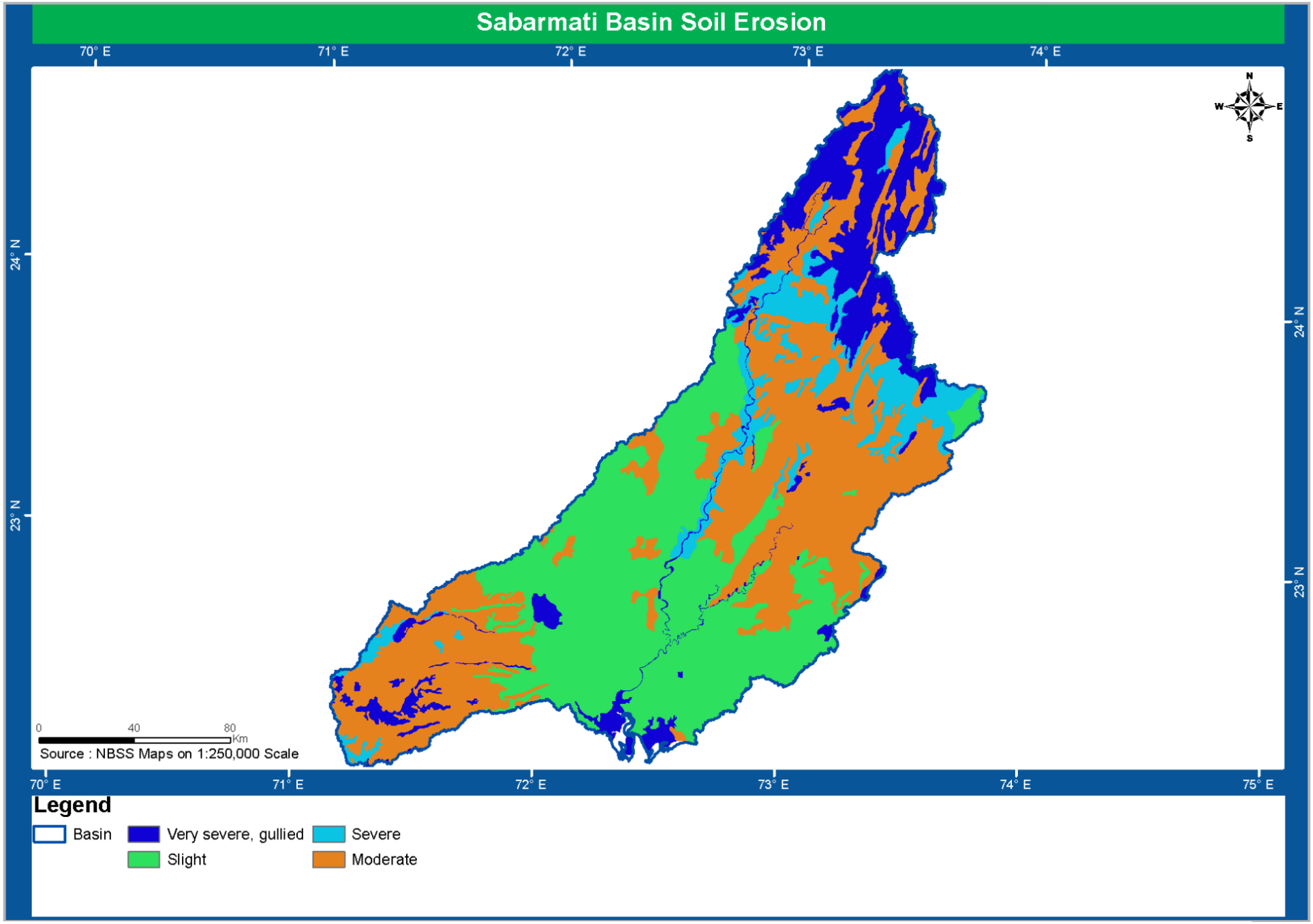
Soil is composed of minerals, mixed with some organic matter, which differ from its parent materials in terms of its texture, structure, consistency, color, chemical, biological and other characteristics. Information on the soil profile is also required for simulating the hydrological character of the basin.

The available information on soil survey conducted in the basin indicates that the basin consists mainly of black, alluvial and sandy soils. The eastern part of Dungarpur and Udaipur districts has mixed red and black soils while the western part has red and yellow soils. Sirohi is a vast sandy plain with isolated hills and rock outcrops. Sabarkantha district has medium black soils occur in the major part of the district, while 'Goradu' soil (rich foam) is found in the western portion. In the district of Panchamahal, the soils are somewhat different from those in the other districts, in that they are residual soils formed by the decomposition of granites and gneisses. The soils are of light color, shallow and infertile, but those situated in the lower plains are darker, clayey and fertile. In Mehsana, except for the western portion of the district which has sandy soils, the rest of the area is covered by 'Goradu' loam. In Ahmedabad, two types, namely black soil and 'Goradu' soil (rich loam) occur and lie close to one another. Soils in the south-west are black and those in the northern and eastern portions are 'Goradu'. Kaira district has four types of soils, namely light reddish brown or Goradu, medium or 'Besar', black or 'Kali' and alluvial or 'Bhata' occur. In Banaskantha district, shallow sandy soils and sandy loams occur. *(Source: Irrigation Commission Report-1972)*

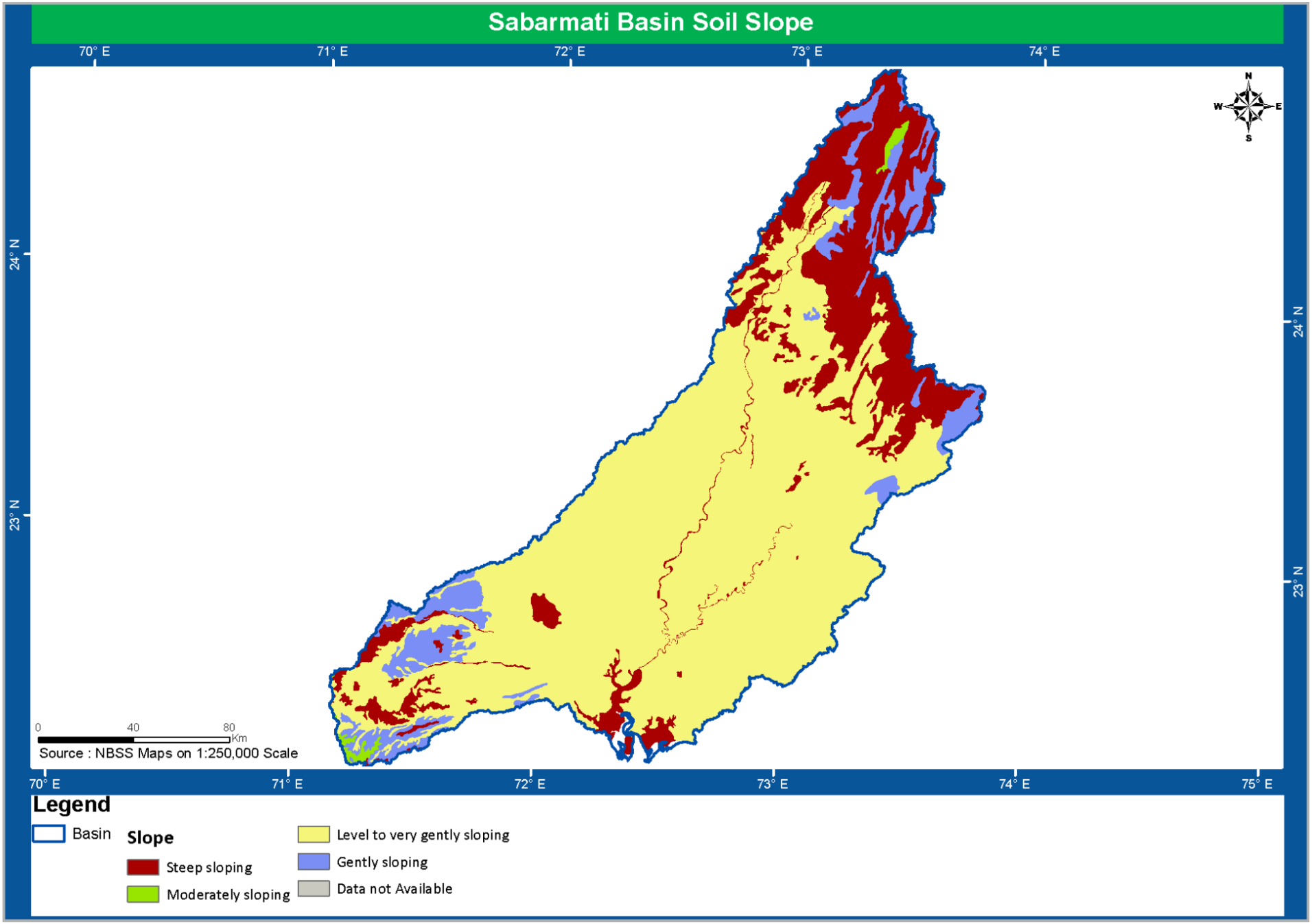
The main soil classification based on soil texture, soil erosion, soil productivity and soil slope in the Sabarmati basin. Based on texture, the larger part falls under fine texture category (60.38%), followed by coarse texture (17.60%), rocky and Waterbodies accounting for 15.26% (Map 7). Around 39.75% of the basin experiences moderate erosion (Map 8). Major portion of the basin is having nearly slope is 71.16%. In the basin 52.09% of soil is highly productive and 7.67 % is moderately productive (Map 9). Based on the depth of the soil groups, about 75.92% falls under the category of moderately shallow to deep (>50 cm), followed by 8.03% extremely shallow (<10 cm) soils (Map 10).



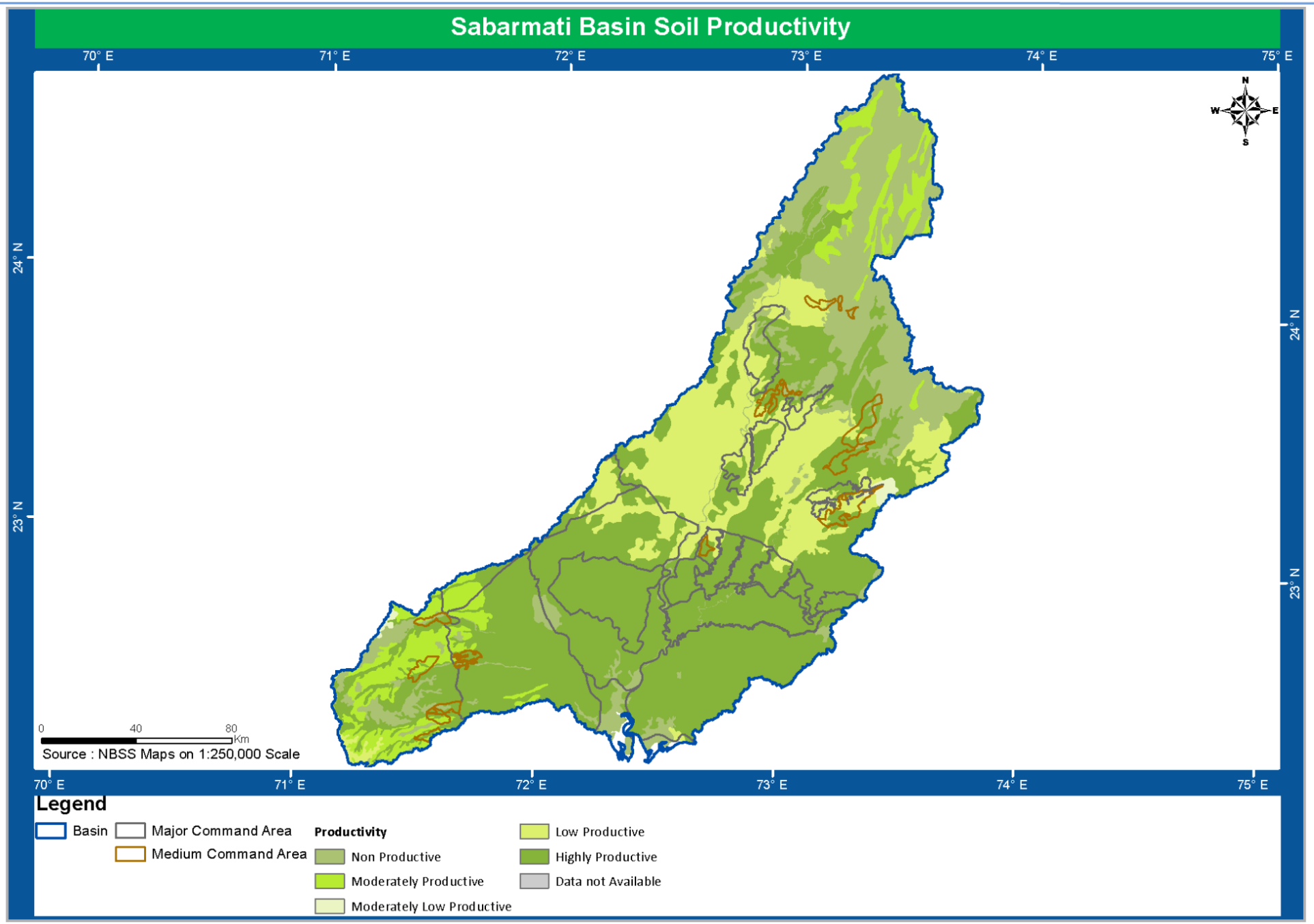
Map 7. Soil Texture



Map 8. Soil Erosion



Map 9. Soil Slope



Map 10. Soil Productivity

1.7 Agro-climatic zones

An agro-climatic zone is a land unit in terms of major climate, and growing period which is climatically suitable for a certain range of crops and cultivators. Sabarmati basin is divided into two agro-climatic zones (Map 11):

(i) Central Plateau and Hills region

(ii) Gujarat Plains and Hills region

(i) Central Plateau and Hills region

The climate of this area is characterized by hot and wet summers and dry winters. The annual precipitation ranges from 500-1000 mm, which covers 40-50% of annual PET demand (1600 to 2000 mm) resulting in gross annual water deficit of 800 to 1200 mm.

The length of growing period ranges from 90-150 days in a year. The dominant soil moisture regime in the area is Typic-ustic, while the dominant soil temperature regime is Hyperthermic. Isohyperthermic regime is observed in coastal areas of Kathiawar peninsula. As such the area has been marked as draught prone area.

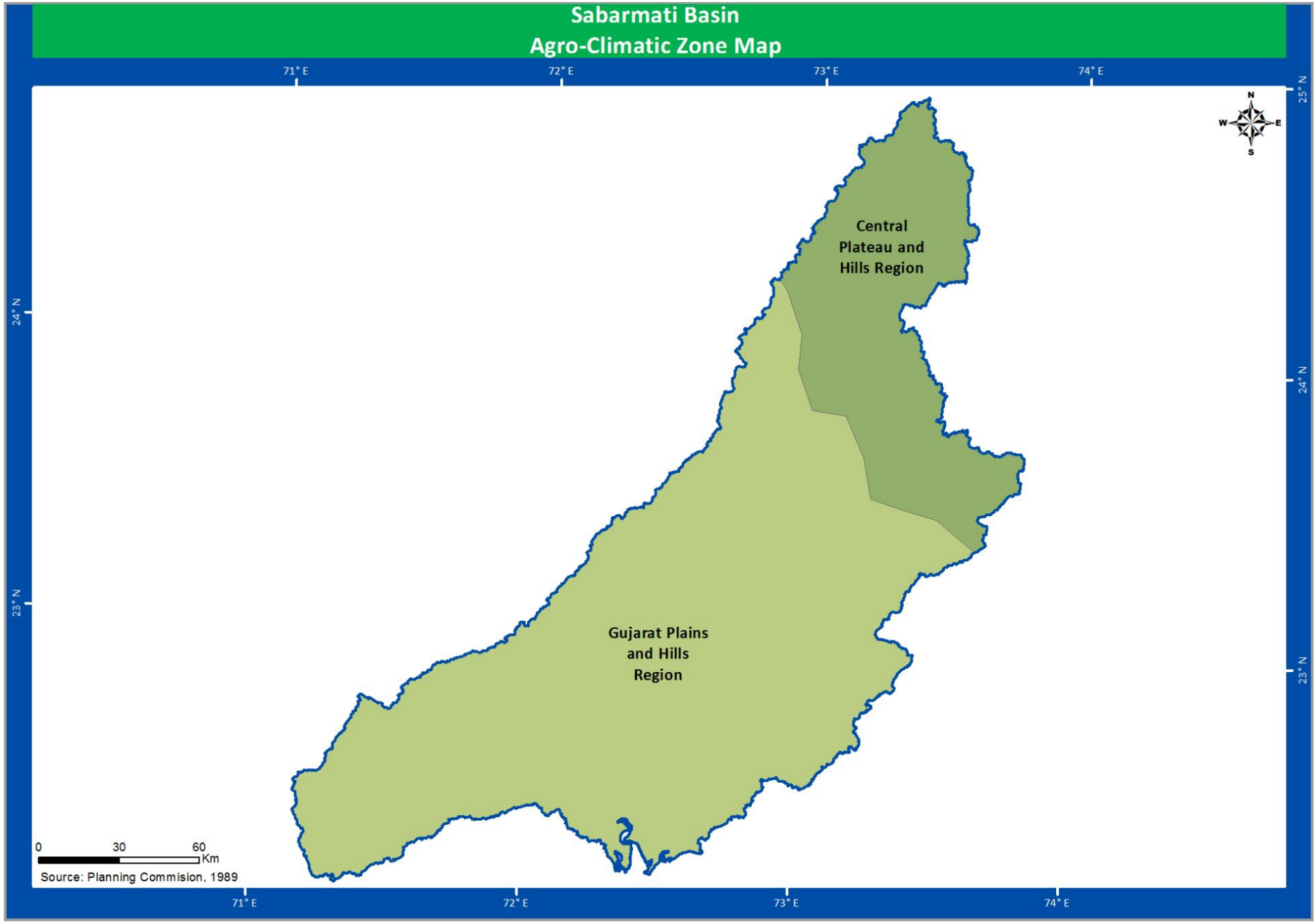
The Central Plateau and Hills region covers parts of Udaipur, Dungarpur (districts of Rajasthan), Banaskantha and Sabarkantha districts of Gujarat.

(ii) Gujarat Plains and Hills region

The climate of the region is characterized by hot and dry summers and cool winters. The annual precipitation in the region ranges between 500 to 1000 mm with an increasing trend from west to east. It covers 35 to 42 % of the mean annual PET demand which ranges between 1400 to 1900 mm. The area shows an annual water deficit of 700-1000 mm.

The LGP ranges between 90 to 150 days. The soil moisture regime is dominated by Typic-ustic while the soil temperature regime is Hyperthermic.

The region of Gujarat Plains and Hills region covers parts of Mehsana, Bharuch, Ahmedabad, Vadodara, Gandhinagar and Anand districts.



Map 11. Agro-Climatic Zones

1.8 Agro-ecological zones

An ecological region is characterized by distinct ecological responses to macro climatic as expressed in vegetation and reflected in soils, fauna and aquatic systems. Therefore an agro-climatic region when it is superimpose on landforms and the kind of soils and soil conditions that acts as modifiers of climate and length of growing period.

On the basis of agro-ecological zones, the basin is broadly divided into 3 zones (Map 12) viz., (i) Hot arid eco-region with desert and saline soil (ii) hot semi-arid eco-region with medium and deep black soils (iii) Hot semi-arid eco-region with alluvium derived soils.

Hot arid eco-region with desert and saline soils

This agro-eco-region covers the western parts of Rajasthan, Kutch peninsula and northern part of Kathiawar peninsula in the basin. The dominant soilscapes, representing the area, are gently to very gently sloping Torripsamments, Camborthids and Calciorthids, interspersed with level to very gently sloping Salorthids and Natrargids. The dominant sandy soils, represented by Thar Series (Torripsamments), are moderately calcareous and alkaline in reaction. In addition, Pali (Camborthids), Lakhpat (Natrargids) and Nihalkhera (Calciorthids) series occur in order of their external distribution. The soils in the eco-region are potentially fertile because of abundant weatherable primary minerals, but their productivity is limited for want of adequate water for irrigation. The natural vegetation comprises sparse, sporadic tropical thorn forest. Rainfed mono-cropping is the traditional practice followed by the farming community. They grow draught resistant and short duration rainy season crops, such as pearl millet, ‘chari’ (fodder), and pulses in non-saline areas. The yields are low under average management practices. In areas favored by availability of irrigation water, cotton, sugarcane, mustard, gram and wheat are grown with better crop yields.

Some parts of Ganganagar, Churu, Bikaner, Sikar, Jaisalmer, Barmer, Pali, Sirohi (districts of Rajasthan), Banaskantha, Western parts of Mehsana, Jamnagar (districts of Gujarat) falls under this zone.

Hot semi-arid eco-region with medium and deep black soils

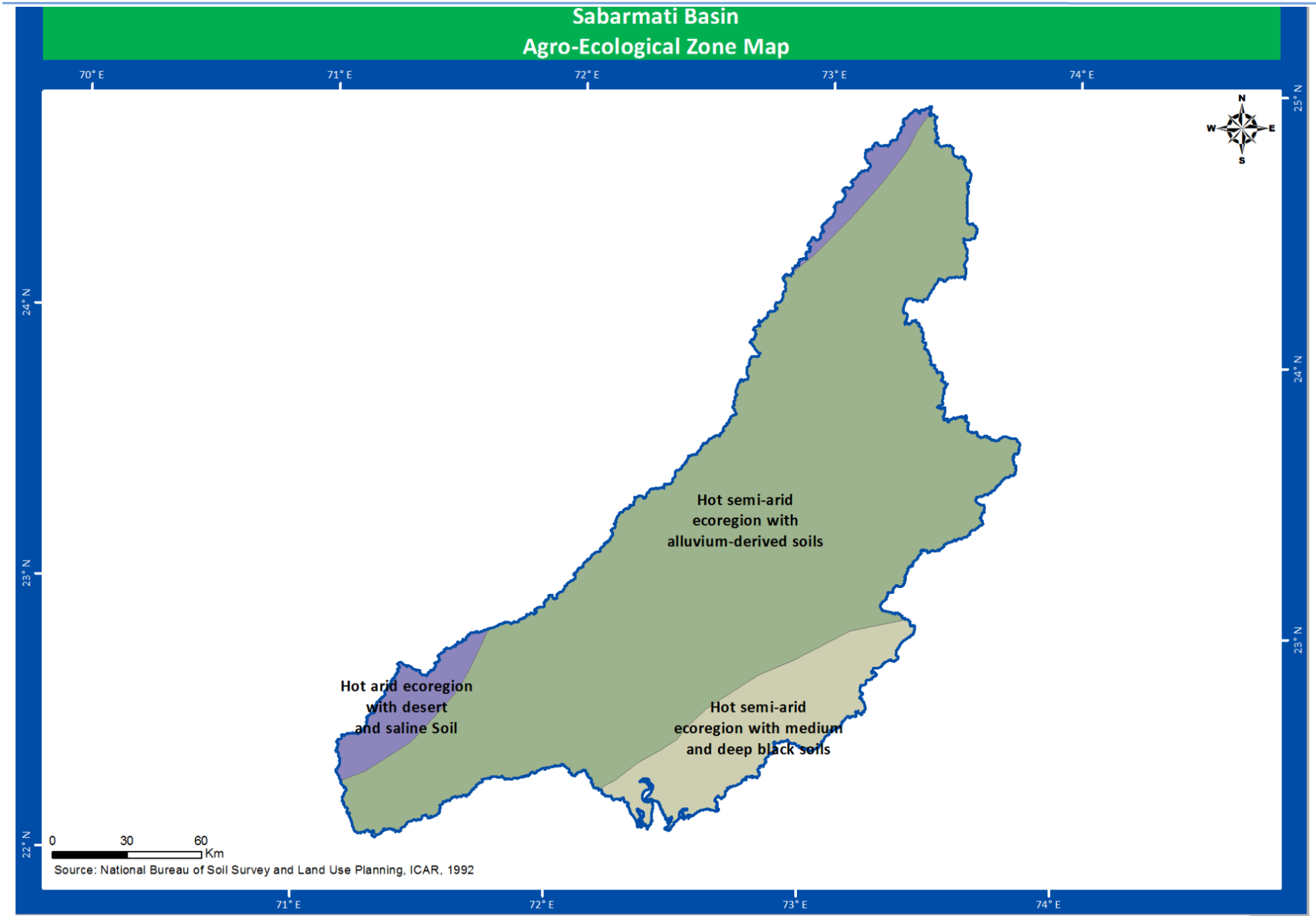
This agro-eco-region covers the central highlands (Malwa), Gujarat plains and Kathiawar peninsula, south-eastern parts of Rajasthan and Gujarat states. The dominant soilscapes, representing the region are gently to very gently sloping deep, loamy to clayey Ustochrepts and nearly level to very gently sloping deep black soils (Chromusterts). In Kathiawar peninsula, the coastal areas, at places are represented by Salorthids. The dominant soils of Malwa plateau are largely typified by Sarol and Kamlia kheri Series. They are clayey, slightly alkaline, calcareous and show characteristic swell-shrink properties. The natural vegetation comprises dry deciduous forest. Dry land farming is the common practice followed in the region. The common kharif crops cultivated in the area are sorghum, pearl millet, pigeon pea, groundnut, soybean, maize and pulses, and the common Rabi crops are sorghum, safflower, sunflower and gram. Wheat is grown under irrigated conditions.

Some parts of Bhavnagar, Junagarh, Vadodara, Rajkot and Surat (districts of Gujarat), Banswara, Chittaurgarh, Jhalawar and Kota (districts of Rajasthan) falls under this zone.

Hot semi-arid eco-region with alluvium derived soils

This agro-eco-region constitutes parts of Gujarat, northern plains and central highlands. The soilscapes in the region vary from moderately to gently sloping, coarse to fine loamy, great slopes of Ustochrepts and Natrustalfs, grading through gently to very gently sloping great slopes of Ustochrepts and Ustipsamments to nearly level Ustifluvents. In the northern part of the region, the terrain is frequently interrupted by stable sand dunes. The soils of the region are dominantly represented by Kanjili series qualifying for Ustochrepts and occasionally by Chomu and Zarifa Viran and Ghabdan series. The Chomu soils are sandy (Ustipsamments), the Zarifa-Viran soils are fine loamy and highly sodic (Natrustalfs) and the Ghabdan soils are fine loamy, highly sodic. The natural vegetation comprise of tropical dry deciduous and tropical thorn forests. Almost65 per cent of the region is under irrigated agriculture, while the remaining parts are under traditional rainfed agriculture. In northern plain, the cultivators have overcome the droughty climate by introducing tube well irrigation, and grow crops with moderately high yields of wheat and paddy. The irrigated areas are intensively cultivated for both kharif and Rabi crops, such as rice, millets, maize, pulses, berseem, wheat, mustard and sugarcane. The predominant Kharif crops grown under rainfed agriculture are Jowar, Pigeonpea and Soyabean, while Rabi crops such as pulses, gram, lentil and wheat are grown on residual moisture with one or two protective irrigation at critical stages of crop growth. The area has high potential for diversification in favour of oilseed crops including sunflower.

The hot semi-arid eco-region with alluvium derived soils zone covers large parts of Ahmedabad, Sabarkantha, Mehsana, Surendranagar (eastern parts) and northern parts of Kheda (districts of Gujarat), Dungarpur, Jaipur, Udaipur, and northern half of Bundi (districts of Rajasthan) falls under this zone. (Source: *Agro-Ecological Regions of India, National Bureau of Soil Survey and Land Use Planning, Nagpur*).



Map 12. Agro-ecological zones

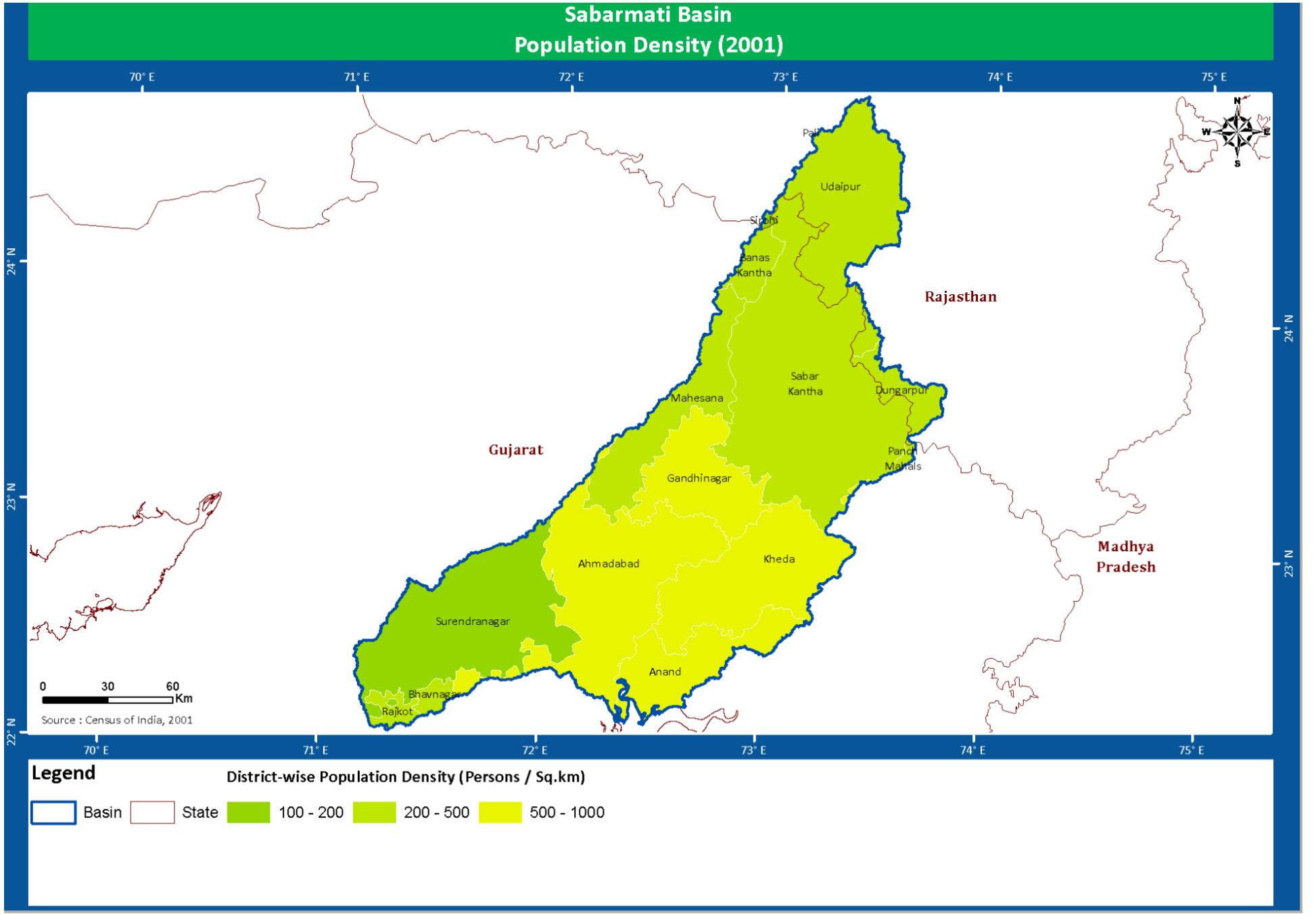
1.9 Demography

Demographics are also used to identify the study of quantifiable subsets within a given population which characterize that population at a specific point in time. Demographic data is used widely in public opinion polling and marketing. Commonly examined demographics include gender, age, ethnicity, knowledge of languages, disabilities, mobility, home ownership, employment status and even location.

The basin spreads over 16 parliamentary constituencies (2009) comprising of 13 in Gujarat, 3 in Rajasthan (Annexure: I B).The total no. of villages falling in the basin is 4,720 with 30,69,264 no. of households (Annexure: III A). The source of drinking water includes wells, tube wells and hand pumps accounting to 8783, 4709 and 7934 respectively. (Annexure: III B)

The district-wise population distribution of Sabarmati basin is shown in Map 13 (as per census data 2001).It depicts that the Ahmedabad, Gandhinagar, Anand, Kheda have more population density compared to the other districts of this basin. As per 2001 census, the total population in the basin is about 13,307,250 which occupies around 14 districts of Gujarat and Rajasthan. The population density varies from region to region. The most densely populated district in the basin is Ahmedabad (Gujarat) while Sirohi (Rajasthan) is the least populated district. The total no. of literates is 90, 50,178 whereas the no. of illiterates is 54,51,073. The basin is well connected through railway network and national highways.

The industrial development in the basin has taken place mainly in the lower part of the basin. The basin is served by a network of the Western Railway of Broad-gauge, Meter-gauge and Narrow-gauge lines. The river and its tributaries are not navigable. The middle and the lower parts of the basin are well served with communications, where as the upper part lacks communication facilities.



Map 13. Population density

2. Hydrological units

Hydrological units of a basin comprise sub basins and watersheds. The Sabarmati basin comprises 2 sub basins and 51 watersheds. The sub basins and watersheds are described below.

2.1 Sub-basins

Semi-automated approach for delineation of hydrological units (basin, sub-basin and watershed) uses SRTM DEM, topo maps on 1:50000 scale, IRS P6 LISS IV and CARTOSAT merged data, drainage network, surface Waterbodies, rail / road network and other ancillary data. Drainage divides from contour/ridge lines are used to demarcate the boundary of hydrological units. The divide has been marked where flow is in opposite directions. Knowledge of terrain as well as DEM is essential for accurate demarcation of boundary. Hydrological boundary has been validated with reference to contours and drainage network. Hydrological unit boundary cuts perpendicular to the contour lines but it does not cross the drainage line at any location except its outlet. This approach is potentially more objective, repeatable, cost-effective, and consistent than previously adopted manual delineation methods.

The Sabarmati basin consists of two major sub basins - *Sabarmati Upper* and *Sabarmati Lower* sub basin. Sei, Wakal, Harnav, Hathmati, Watrak are some major tributaries contributing to the Sabarmati Upper sub basin which covers about 64.58% of the total geographical area of the basin. Sabarmati lower sub basin is smaller than the Sabarmati upper sub basin covering 35.42% of the total geographical area of the basin. Major tributaries contributing to the lower Sabarmati sub basin are Bhogavo, Goma, Bhadar River, Limbadi- Bhogavo, Umai, Salva etc.

The percentage area covered by sub-basins in the basin is given in Figure 4.

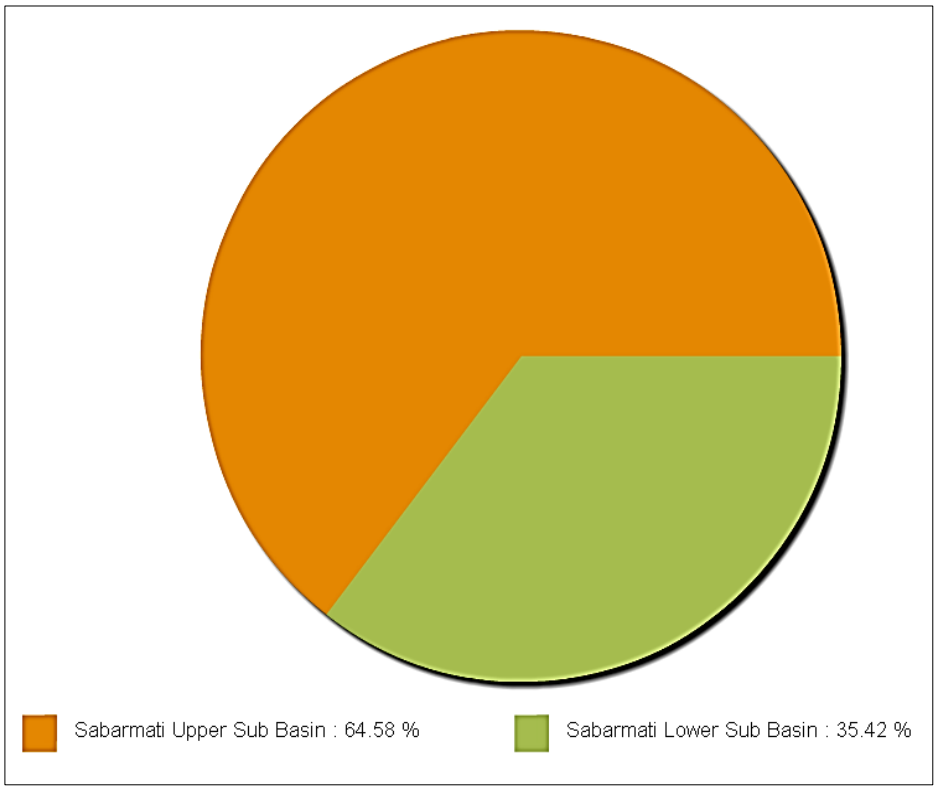


Figure 4. Sub-basins and per cent drainage area

2.2 Watersheds

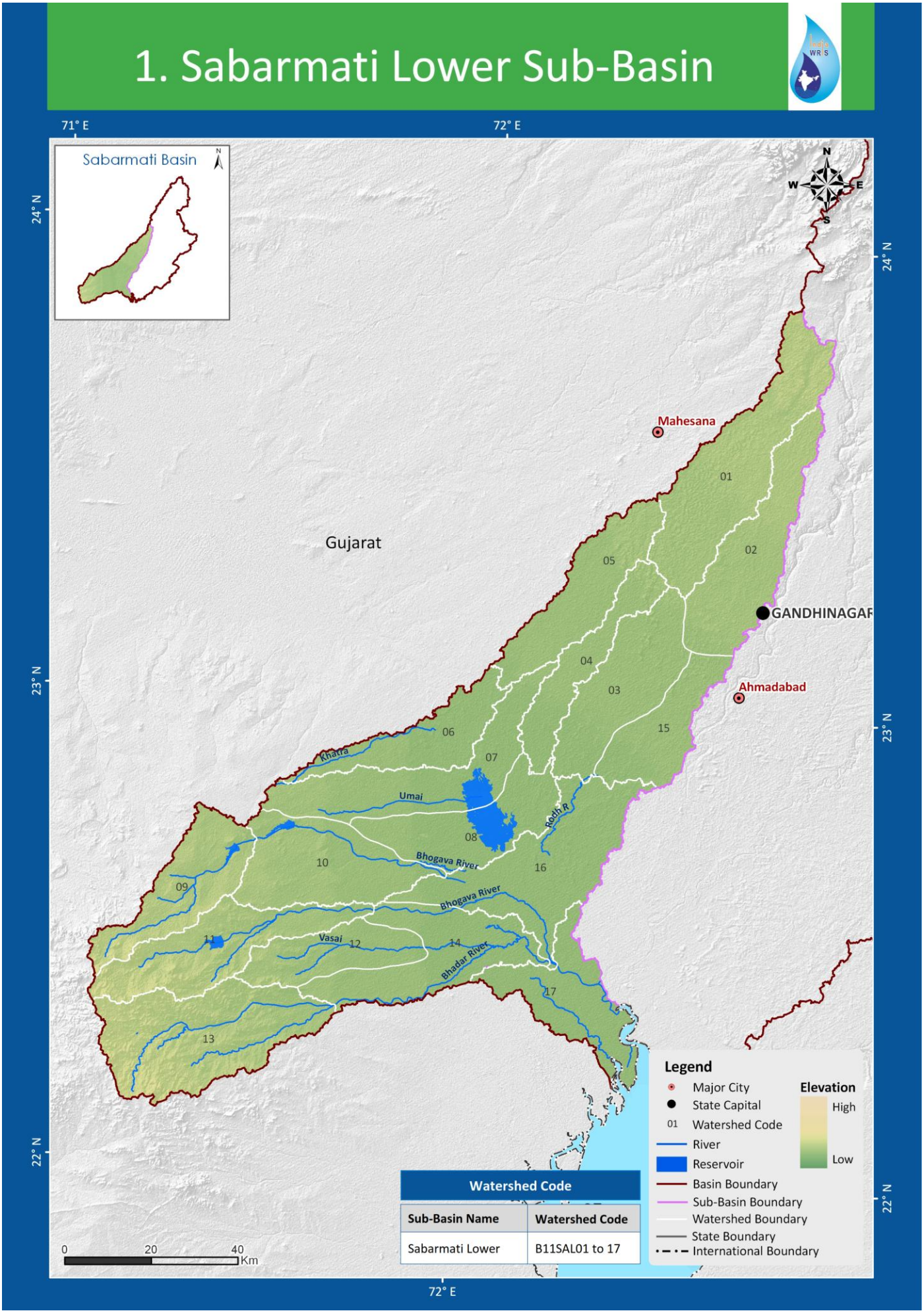
Hydrological unit wise assessment of water resources is a pre-requisite for its proper management as it is fast becoming scarce in India. Sub-basins could be sub divided into smaller hydrological units namely, watershed for water resources management at larger scale (micro level). Watershed is a natural hydrological entity that covers a specific areal expanse of land surface from which rainfall flows to a defined drain, channel, stream or river at any particular point. Watershed should be delineated purely on the basis of hydrologic principles. Size of the watershed is governed by the size of stream and its boundaries.

Two sub-basins have been further bifurcated into 51 watersheds. Sabarmati lower sub basin consists of 17 watersheds with size range of 397.55 - 986.46 Sq. km. Sabarmati upper sub basin consists of 34 watersheds with size range of 313.38 - 828.34 Sq. km. Maximum number of watersheds are falling in Sabarmati upper sub-basin. The number and size range of watershed under each sub-basin is given in Table 5. Spatial location of the watersheds in Sabarmati lower sub-basin is shown in Map 14(a) whereas the location of watersheds in Sabarmati upper sub-basin is shown in Map 14(b).

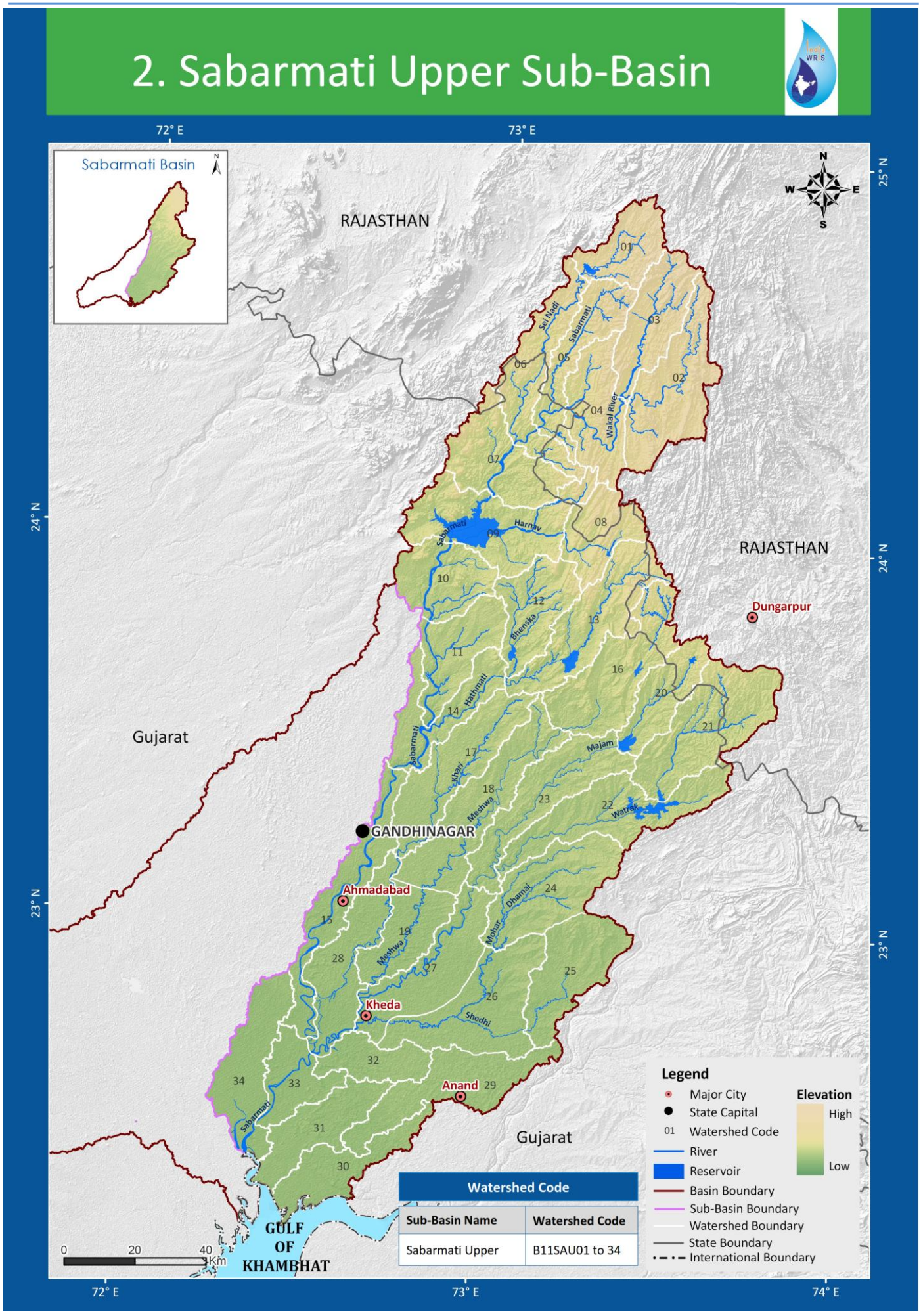
Each watershed is given an 8 digit alphanumeric code for identification. Each letter in the code has a description. For example if Watershed code is B11SAU01, the first alphabet (**B**11SAU01) stands for the Water resource region (India-WRIS). Following 2 digits represents basin code (B**11**SAU01). Next three letters (B11**SAU**01) represents sub basin name which is followed by watershed number (B11SAU**01**).

Table 5. Sub-basin wise watersheds

S. No.	Name of Sub-basin	Area (Sq. Km.)	Size Range of Watershed (Sq. Km.)	No. of Watersheds
1	Sabarmati Lower Sub Basin	8904.02	397.55 - 986.46	17
2	Sabarmati Upper Sub Basin	40575.72	313.38 - 828.34	34



Map 14(a). Sabarmati Lower sub-basin and watersheds



Map 14(b). Sabarmati Upper sub-basin and watersheds

3. Surface water resources

3.1 Surface waterbodies

Sabarmati basin is endowed with enormous surface water resources. The large perennial river and other waterbodies with the rich aquifer speak about vastness of its water resources. Surface water is available in the forms of river, stream, lake, swamps, pond etc. Although there is seasonal and regional variation in the availability of water resources, the annual availability of water resource remain almost same. In the last few decades the use of water has been growing at a fast rate, which is more than twice the rate of the increase of human population. The consumption of water has increased due to the increase of human population as well as the diversification of human activities. With the increase of per capita consumption of water in domestic, agricultural and industrial sectors, cause the reduction of potential per capita availability of water. Moreover, it may cause the deterioration of water quality to a great extent.

Surface Waterbodies have traditionally played an important role in the lives of common people in India by way of irrigation, drinking water supply, ecology, tourism and domestic uses. Sabarmati basin as on today possesses some major water reservoirs.

In the Sabarmati basin, there are 3247 Waterbodies, which include lakes/ponds, tanks, aquaculture pond, reservoir, ox-bow Lake and cooling pond. Majority of the surface Waterbodies are tanks (91.62 %) and lakes/pond (5.97%). A very few Waterbodies are come under cooling pond, aquaculture and ox-bow lake, which constitute less than 5 % of total Waterbodies in the basin (Figure 5).

Reported average annual water potential of Sabarmati basin is 3.81 BCM. The utilizable surface water resources in the basin is 1.90 BCM. The most of Waterbodies in the basin are less than 25 ha size, whereas very few waterbodies having more than 2500 ha in wide. A detail of number of Waterbodies according to their water spread area is given in Table 6.

Table 6. Number and size of waterbodies

Sl. No.	Size Range (ha)	No. of Waterbodies
1	0 - 25	3056
2	25 - 50	96
3	50 - 100	55
4	100 - 250	24
5	250 - 500	5
6	500 - 1000	6
7	1000 - 2500	1
8	More than 2500	4

**Source: India-WRIS database*

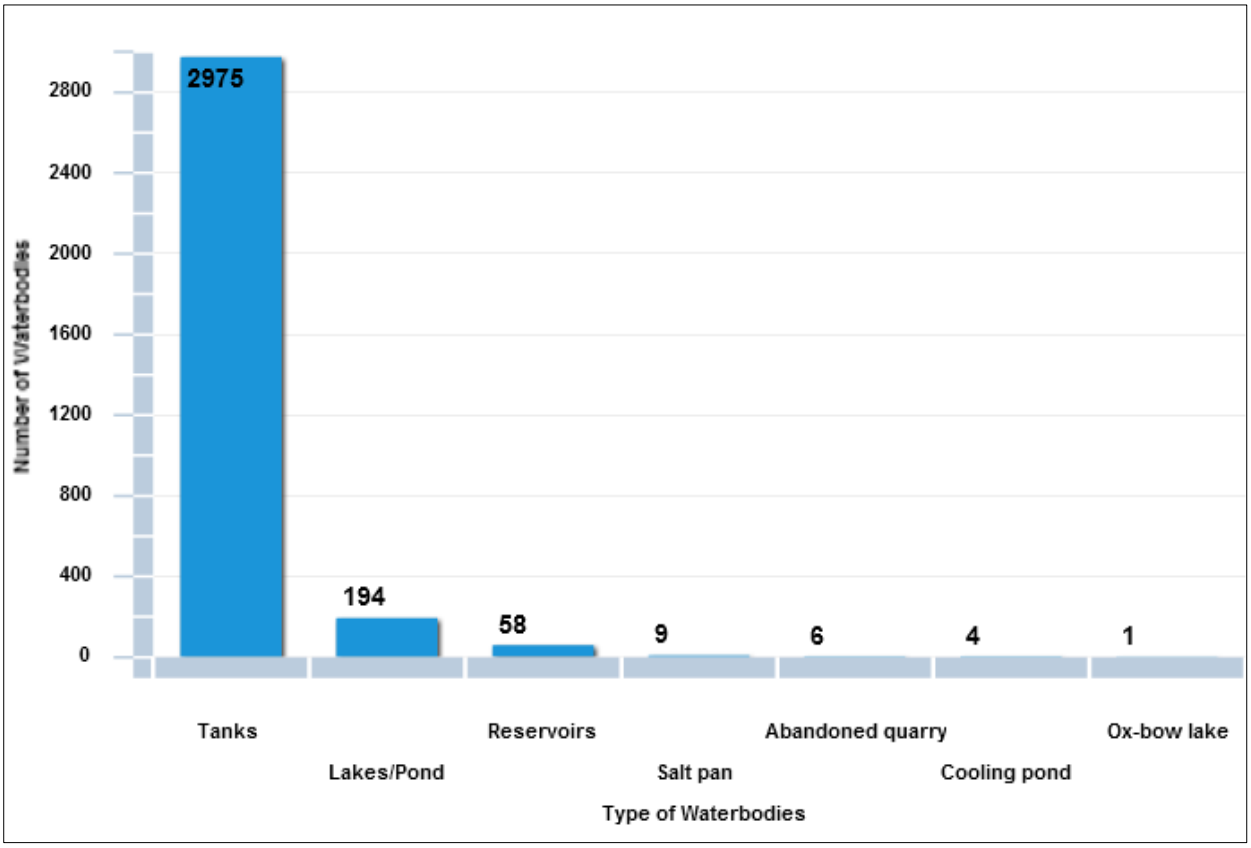


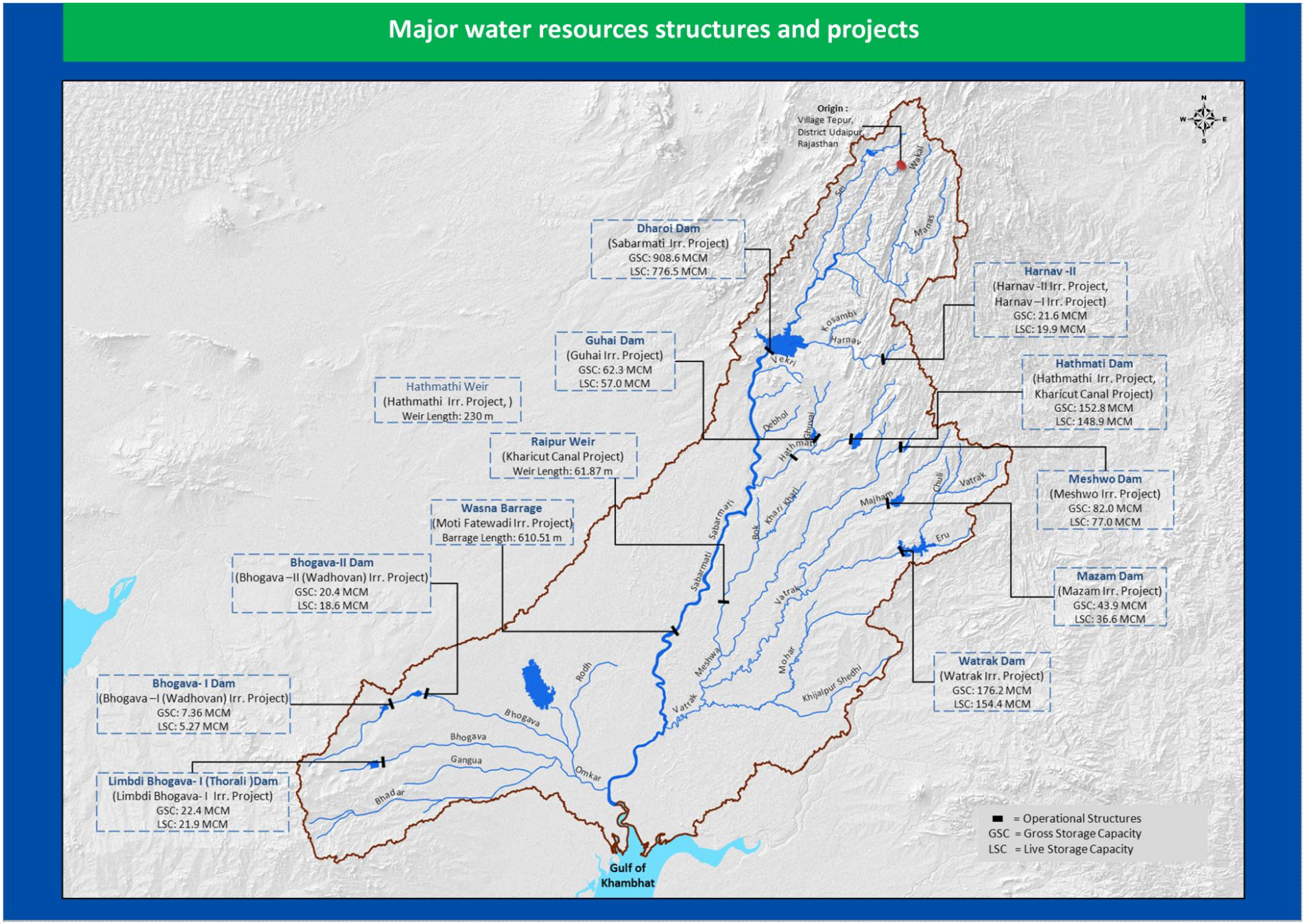
Figure 5. Type and number of waterbodies

3.2 Water resources projects

Water resources projects are broadly categorized into irrigation projects and hydroelectric projects. These projects are planned for various purposes like irrigation, hydro-power generation, water supply for drinking and industrial purpose, flood control navigation etc. Projects which serve more than one purpose are called as multi-purpose projects. Generally majority of multipurpose projects are combination of irrigation and hydro-power. There are many irrigation, hydro-power and multipurpose projects which were approved initially as independent projects. Subsequently due to interstate agreements and new projects coming up on downstream and upstream, water planning was done in such a way that operation of these projects are now done in an integrated manner. Such types of projects are now being called as irrigation, hydro power, multipurpose and complex.

3.2.1 Major and medium irrigation projects

The total live storage capacity is 1.45 BCM (completed- 1.30 BCM, Under-construction- 0.06 BCM and under- consideration- 0.09 BCM). There are 9 Major and 11 Medium irrigation projects in the basin. some important projects in the Sabarmati basin constructed during plan period are Sardar Sarovar Major Irrigation Project (Gujarat), Mahi Stage-I (Wanakbori) Major Irrigation Project, Motifatewadi Major Irrigation Project, Sabarmati (Dharoi) Major Irrigation Project, Sei Medium Irrigation Project, Watrak Major Irrigation Project, Hathmati Major Irrigation Project, Meshwa Major Irrigation Project, Kharicut Canals Major Irrigation Project and Meshwo Canal Major Irrigation Project.



Map 15. Major water resources structures and projects

Details of Major and Medium irrigation projects are given in Annexure: IV C and D. Sub basin wise water resources assets are mentioned in Map 16 (a) and 16 (b). List of type and number of water resources projects is given in the Table 7 below.

Table 7. Number of water resources projects

Sl. No.	Type of Projects	Number of Projects
1	Major Irrigation Projects	9
2	Medium Irrigation Projects	11
3	ERM Projects	4
4	Hydro-Electric Projects	0

Some important water resources projects in the basin are described below.

Sabarmati (Dharoi) Project: This project is located on Sabarmati River near village Dharoi in Kheralu taluka of district Mehsana, 103 km from the source of the river. The project comprised of a composite dam across Sabarmati River having ogee type spillway of length 219 m. The length at top of dam is 1207 m and maximum height above the lowest point of foundation is 46m. The catchment area of this project is 5539.98 Sq. km. The live storage capacity of the reservoir is 776.5 MCM and gross storage capacity is 908.6 MCM. The estimated cost of the project is Rs. 125.74 Crores. Total CCA of the project is 57.99 Th ha and ultimate irrigation potential is 64.75 Th ha.

Watrak Project: This project is located in village Pahadia of Malpur tehsil in district Sabarkantha of Gujarat. The project comprised of a composite dam across Watrak River having ogee type spillway of length 89 m. The length at top of dam is 325 m and maximum height above the lowest point of foundation is 43.31 m. The catchment area of this project is 1114 Sq. km. The live storage capacity of the reservoir is 154.4 MCM and Gross storage capacity is 176.2 MCM. The estimated cost of the project is Rs. 47.58 Crores. Total CCA of the project is 18.34Th ha and ultimate irrigation potential is 16.87 Th ha.

Sardar Sarovar Major Irrigation Project: This project is located near Rajpipla. This project envisages construction of a composite dam across Narmada River having ogee type spillway of length 749.60 m. The length at top of dam is 1210 m and maximum height above the lowest point of foundation is 163 m. The catchment area of this project is 88000 Sq. km. The live storage capacity of the reservoir is 5800 MCM. The estimated cost of the project is Rs. 39,240.45 Crores. Total CCA of the project is 2,120 Th ha and ultimate irrigation potential is 1,792 Th ha.

Hathmati Major Irrigation Project: This project is located near Bhiloda. This project envisages construction of a composite dam across Hathmati River having ogee type spillway of length 241 m. The length at top of dam is 993 m and maximum height above the lowest point of foundation is 23.62 m. The catchment area of this project is 594.95 Sq. km. The live storage capacity of the reservoir is 148.93 MCM and gross storage capacity is 152.8 MCM. The estimated cost of the project is Rs. 5.71 Crores. Total CCA of the project is 17.49 Th ha and ultimate irrigation potential is 44.52 Th ha.

Lift irrigation and ERM

There are 4 ERM projects in the Sabarmati basin (Annexure: IV D) namely the Extension of Dharoi of RBMC, Hathmati Modernization, Modernization of Motifatewadi and Modernization of Kharicut Canal (Table 7). No major Lift irrigation scheme exists in the basin.

3.2.2 Hydro Electric projects

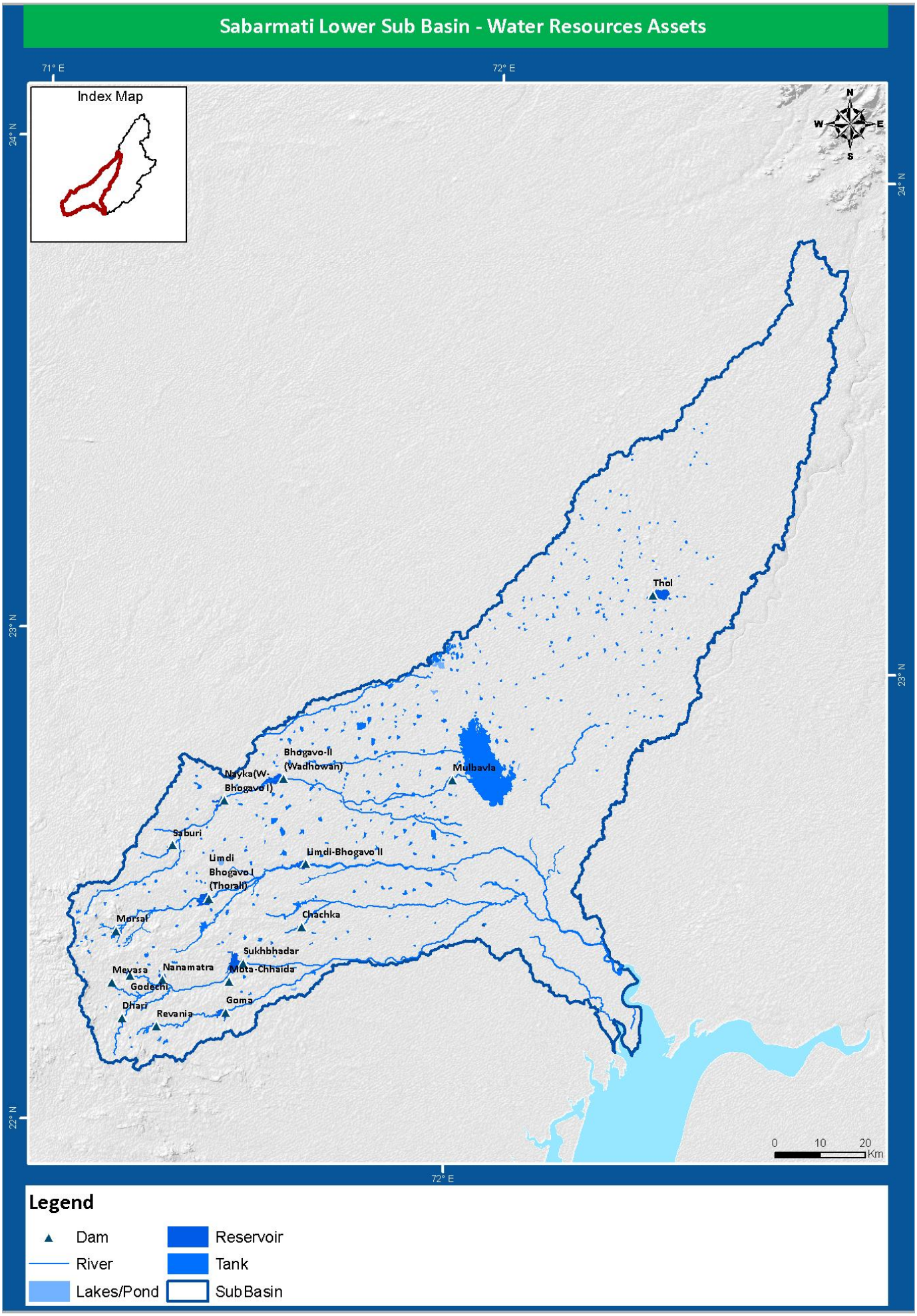
No hydro-electric projects and powerhouse exist in the Basin.

3.2.3 Dams, Barrages/Weirs/Anicuts

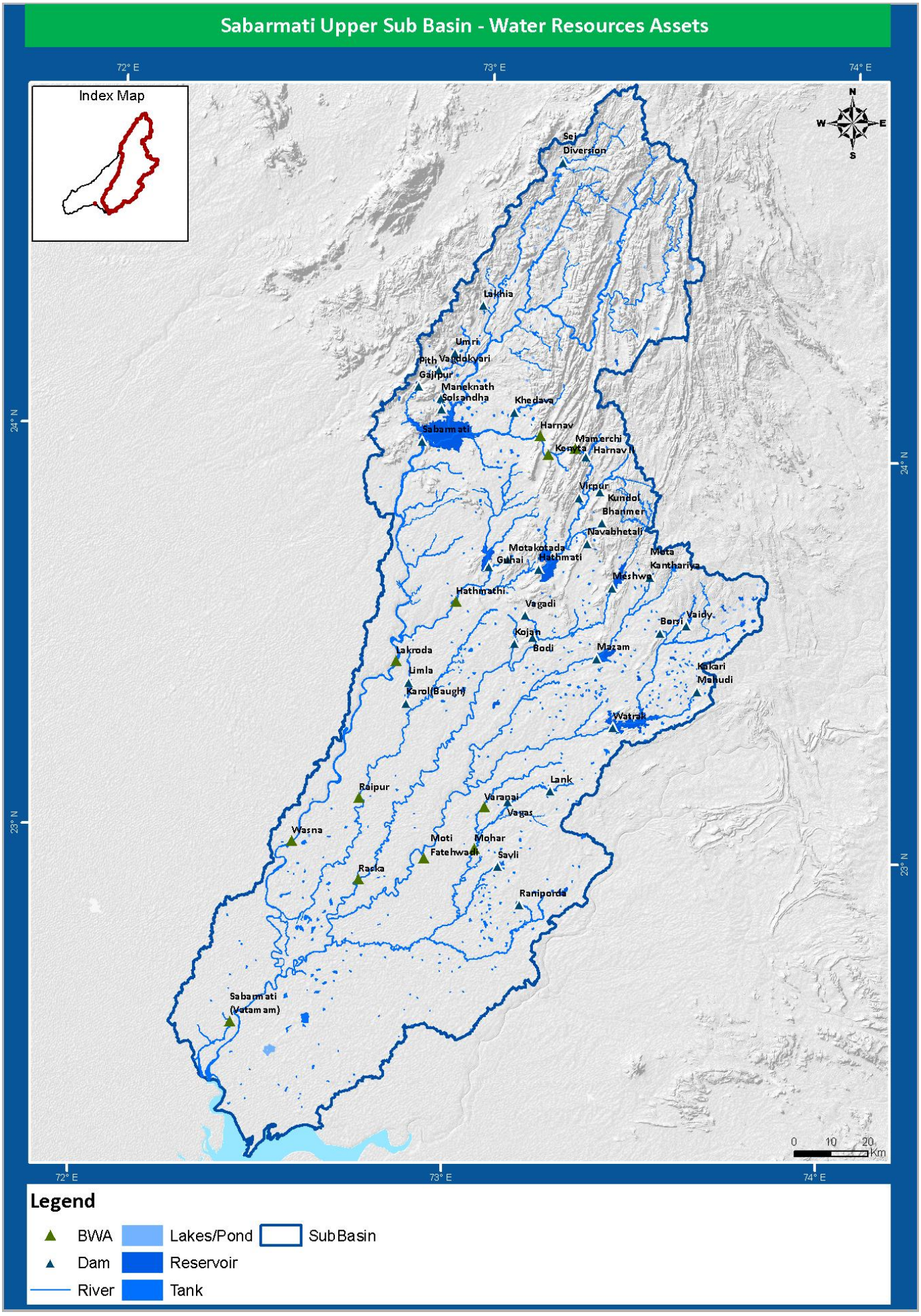
Water resources structures are manmade structures to store the water for hydropower, irrigation, Drinking and water supply etc. As per available data (India-WRIS), there are a total of 50 Dams in the Sabarmati basin among which 17 dams fall in Sabarmati lower sub basin and 33 dams,10 weirs, 2 barrages fall in the Sabarmati upper sub basin (Table 7). Around 91.67 % dams are used for the purpose of irrigation (Map14). Majority of dams (81.25%) have a storage capacity of 0-25 MCM (Figure 6).The longest dam in the basin is Sabarmati (Dharoi) dam located in Gujarat with a total length of 46 m and 776.5 MCM live storage capacity. The highest dam in the basin is mulbavla dam with a height of 9735 meters. There are 2 barrages and 10 weirs in the basin (Table 8). The Wasna barrage (20.75 m) is the highest and the Varanai barrage (1544 m) is the longest barrage located on Sabarmati River. Salient features of the dams, barrages and weirs of the Sabarmati basin are listed in the Annexure: IV under the Inventory of surface water resources**.** The location of major water resources structures and respective projects is shown in the Map 15 along with the rivers. The map depicts an overview of the basin in terms of water resources assets and projects.

Table 8. Sub-basin wise number and type of water resources structures

Sl. No.	Sub Basin	Dams	Barrages	Weirs	Anicuts	Lifts	Power House
1	Sabarmati Lower Sub Basin	17	0	0	0	0	0
2	Sabarmati Upper Sub Basin	33	2	10	0	0	0



Map 16(a). Sabarmati Lower sub-basin and water resources assets



Map 16(b). Sabarmati Upper sub-basin and water resources assets

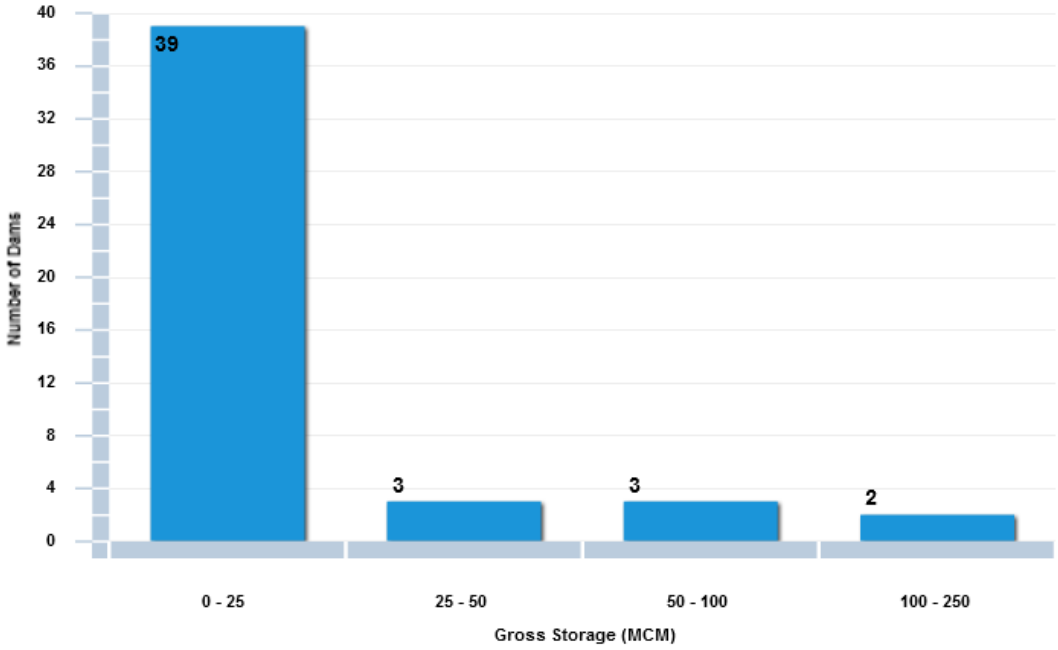


Figure 6. Dam classification based on storage

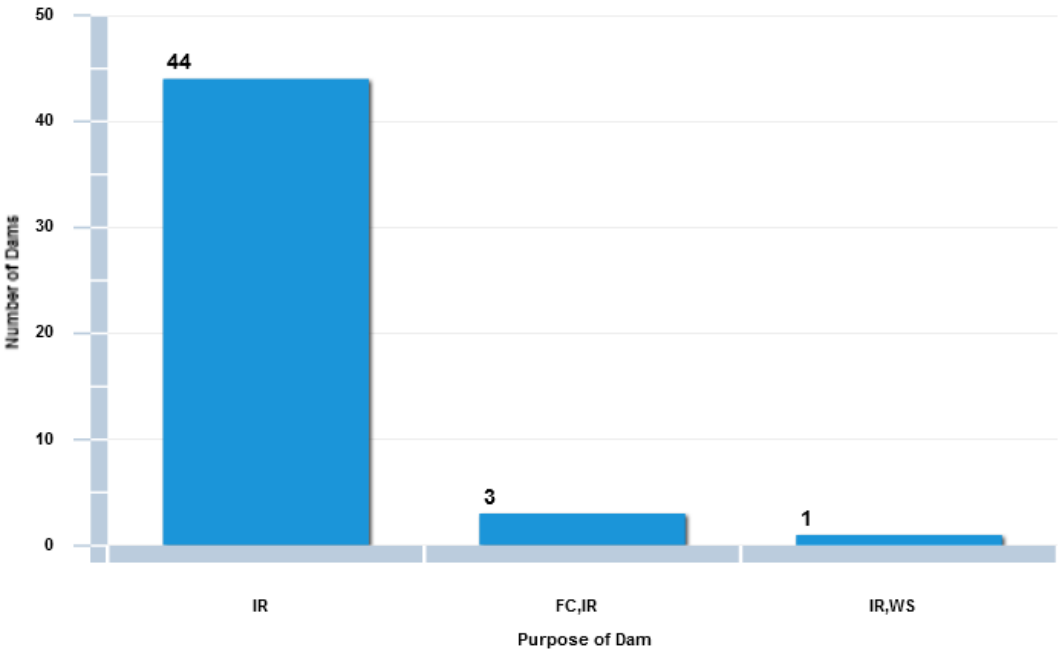


Figure 7. Dam classification based on purpose

3.2.4 Command area and canal network

Culturable command area is the basis for the design of water course and design of an irrigation project. It is the proportion of the gross command area which is culturable and cultivable. The Planning commission has classified the irrigation in India in three types:

- **Major irrigation Scheme**: Major irrigation schemes are those schemes which have a CCA of more than 10,000 Ha.
- **Medium irrigation Schemes**: The medium irrigation schemes have a CCA of 2,000-10,000 Ha.
- **Minor Schemes**: Those with CCA up to 2,000 Ha.

Canals are man-made channels for conveyance of water. When the water is to be transported across landscape to deliver the water to the respective command areas by canal network, construction of various irrigation structures are necessary to negotiate terrain including drains, road, rail lines. Important irrigation structures are Regulators, Bridge, Aqueduct / Siphon Aqueduct, Super passage / Siphon, Level crossing / Inlets and Outlets, and other cross drainage structures. Distributary head regulator controls the supply to an off taking channel from the parent channel

The basin has 3 AIBP projects namely Sardar Sarovar II A, Sardar Sarovar II B and Watrak projects. The total length of the canal is 3573.80 Sq. km. The salient features of important AIBP projects are given below:

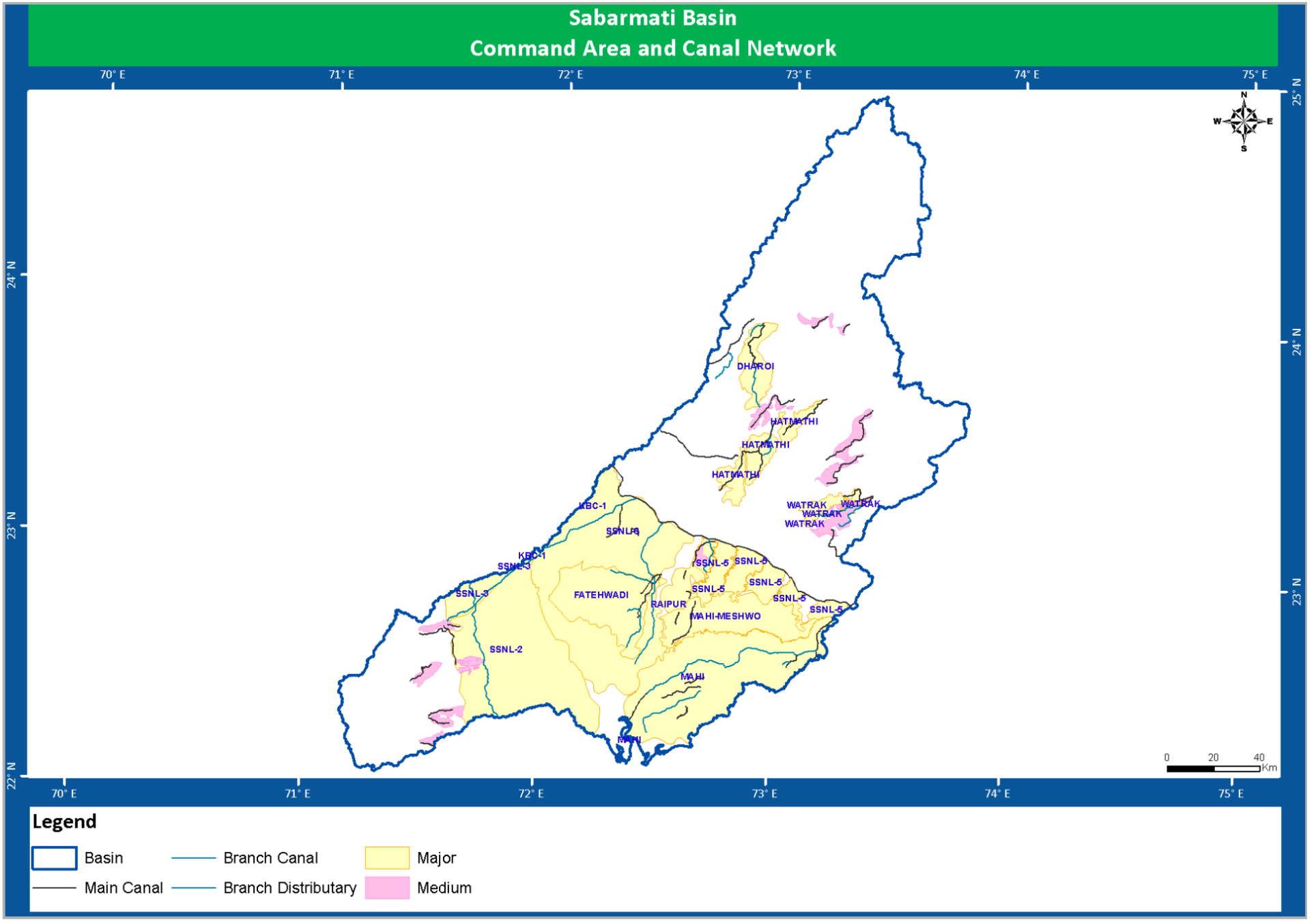
Sardar Sarovar project II-A is an AIBP project, being executed in Sabarmati basin. A large network of canals, comprising of 1 main canal, 14 branch canals, 60 distributaries and 319 minor canals has been constructed over the Sardar Sarovar project II -A.

Sardar Sarovar project II-B is also an AIBP project, being executed in Sabarmati basin. A large network of canals, comprising of 1 main canal, 2 branch canals and 8 distributaries has been constructed over the Sardar Sarovar project II -B.

Watrak Project is an AIBP project, being executed in Sabarmati basin. A large network of canals, comprising of 2 main canal, 2 branch canals, 4 distributaries, 14 minor and 4 sub minor canals has been constructed over the Watrak Project.

The Basin has 40 command areas, out of which 20 are major and 20 are medium commands. Watrak Major Irrigation Project, Mahi Stage-I (Wanakbori) major irrigation project, Hathmati major irrigation project and Meshwa major irrigation project are some of the major commands in the basin. Hathmati canal system is one of the oldest irrigation systems of Gujarat state. The major and medium commands along with respective canal network (Main, Branch and Branch Distributary) are shown in the Map 17.

A study was carried out jointly by CWC & ISRO to assess the existing status of the irrigation commands. IRS P4 LISS III data of two different seasons namely, pre monsoon (2005) and post monsoon (2004) were used for delineation of waterlogged and salt affected areas of major and medium irrigation commands of Sabarmati basin. Total waterlogged area in the basin is 1200.35 Sq. km. whereas the salt affected area is 657.18 Sq. km.



Map 17. Command area and canal network

3.2.5 Multi-purpose project

There are 2 multi-purpose projects in the basin viz., Mahi Kadana multi- purpose project and Sardar Sarovar multi- purpose project.

Mahi Kadana multipurpose project consists of Mahi Stage - I (Wanakbori), major irrigation project, Mahi Stage - II (Kadana) major irrigation project, Mahi Bajaj Sagar dam major irrigation project (Gujarat), Mahi Bajaj Sagar dam major irrigation project (Rajasthan) and Kadana hydroelectric project.

Sardar Sarovar multi-purpose project consists of Sardar Sarovar major irrigation project in (Gujarat) Narmada Canal major irrigation project (Rajasthan) and Sardar Sarovar hydroelectric project.

3.2.6 Interstate project

Sardar Sarovar Interstate Project is a part of Sabarmati basin. It covers the states of Gujarat and Rajasthan. Sardar Sarovar Interstate Project is another important project in the basin. It comprises of Narmada Canal Major Irrigation Project in Rajasthan and Sardar Sarovar Major Irrigation Project in Gujarat.

4. Ground water resources

4.1 Ground water observation wells

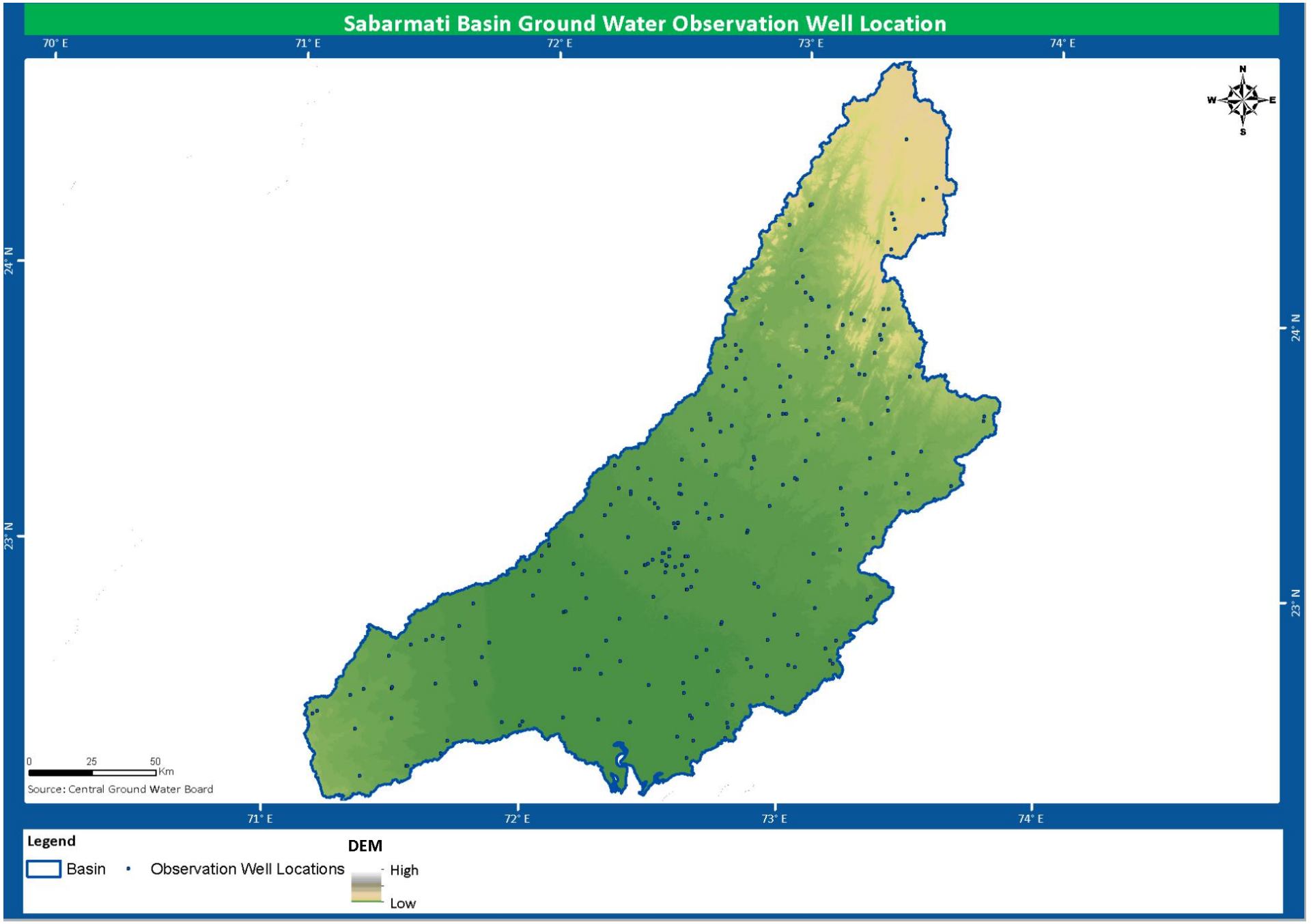
Water is essential to sustain agricultural growth and productivity. Ground water is the water below the surface of the earth that occurs in soil pores and in cracks and fissures in rocks. Typically, Ground water is liquid flowing water but the definition also includes soil moisture, perma-frost (frozen soil) and water trapped in very low permeability bed rocks. A unit of rock containing a usable amount of water is termed as an aquifer. Ground water is refurbished from the surface and eventually flows back to the surface in the form of springs or oasis. The occurrence of Ground water generally depends upon the rainfall, drainage, topography and the geological conditions of the area.

In Sabarmati basin, there are 243 observation wells (dug well / tube well / bore well) which area well distributed throughout the basin. Out of 243 observation wells, 93 wells fall in Sabarmati lower sub basin and 150 wells fall in Sabarmati upper sub basin as given in Table 9. These wells show four seasonal water level data viz., pre-monsoon, monsoon, post-monsoon and post-monsoon (Rabi). Map 18 shows distribution of Ground water observation wells in the basin.

Ground water is used for mainly two purposes at large scale in the basin which includes drinking and irrigation.

Table 9. Sub-basin wise number of ground water observation wells

Sl. No.	Sub Basin	No. of Observation Wells
1	Sabarmati Lower Sub Basin	93
2	Sabarmati Upper Sub Basin	150



Map 18. Location of ground water observation wells

4.2 Ground water level fluctuation

The occurrence of Ground water generally depends upon the rainfall, drainage, topography and the geological conditions of the area. Ground water fluctuation in the Sabarmati basin is assessed for recharge and draft conditions based on the available Ground water level in four different seasons. Ground water recharge is estimated by the difference between pre and post monsoon seasons. Similarly, Ground water draft is estimated by the difference between post-monsoon and post-monsoon (Rabi) seasons data. Interpolated maps for Ground water recharge and irrigation draft (Rabi) are prepared based on the available Ground water fluctuation data in the basin.

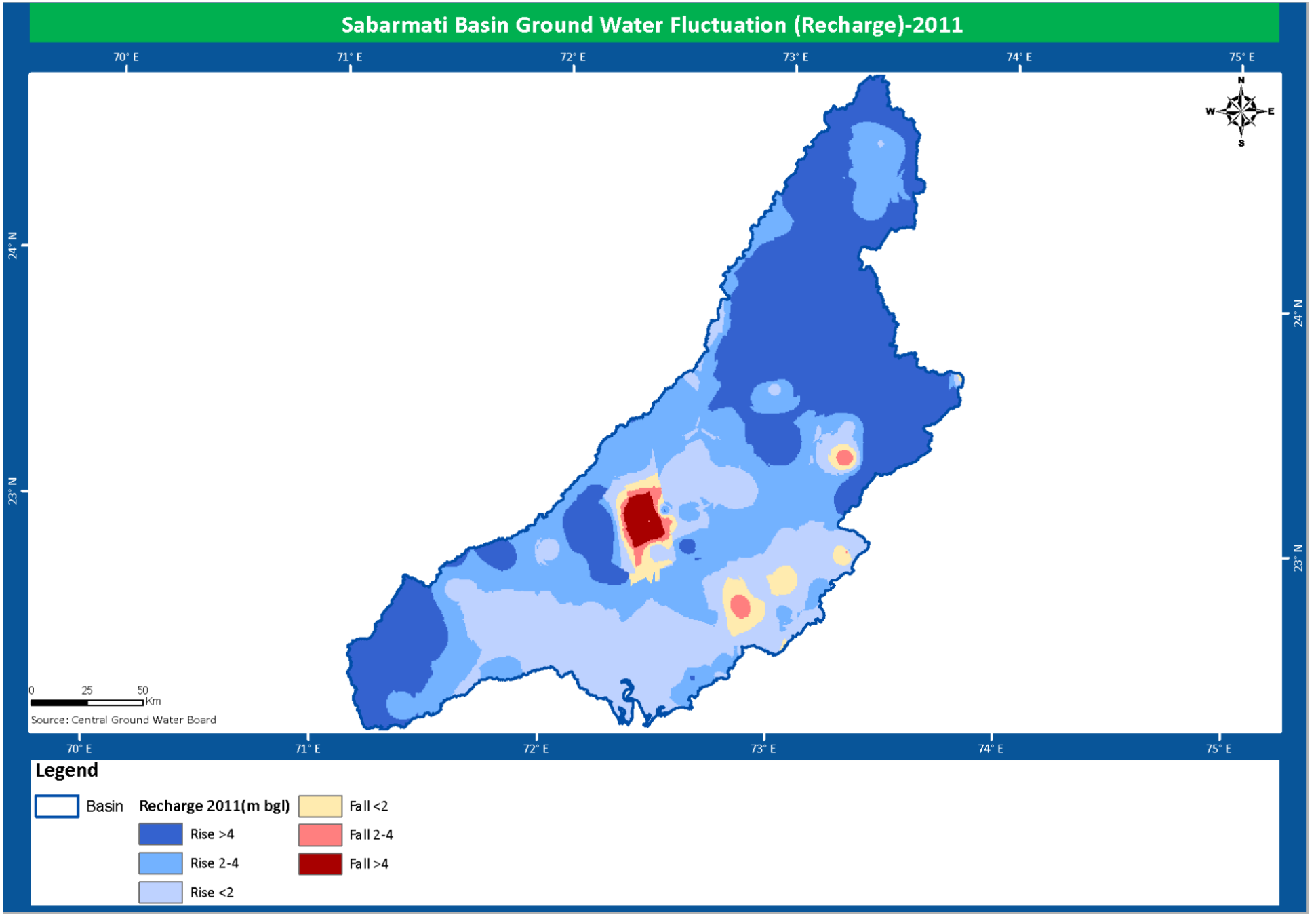
In Sabarmati basin, Ground water fluctuation is assessed for 93 observation wells in Sabarmati lower sub basin and 150 observation wells in Sabarmati upper sub basin. Ground water fluctuation maps due to recharge and draft in 2011 are shown in Map 19 and Map 20 respectively. It has been observed that Sabarmati upper sub basin is a good recharge area with rise in Ground water level (positive Ground water fluctuation) up to 4 meters. Marginal fall in Ground water level in post-monsoon period is observed in the central part of the Sabarmati basin. During Rabi season, a significant Ground water fluctuation due to irrigation draft is observed in the Sabarmati upper sub basin as well as in the Sabarmati lower sub basin with fall in Ground water level for 2-4 m (Map 19). However, a marginal improvement in irrigation draft (rise in Ground water fluctuation up to 4 m) is observed in the central part of Sabarmati basin.

The Ground water fluctuation due to recharge (2011) is shown in the Map 19 which shows water level rise of > 4 m in parts of Banaskantha, Sabarkantha, Kheda, Surendranagar, Rajkot, Panchmahal districts of Gujarat, Udaipur, Dungarpur and Sirohi districts of Rajasthan falling in Sabarmati basin. Ahmedabad, Gandhinagar and Mahaska districts of Gujarat, observed a rise of 2 - 4 m.

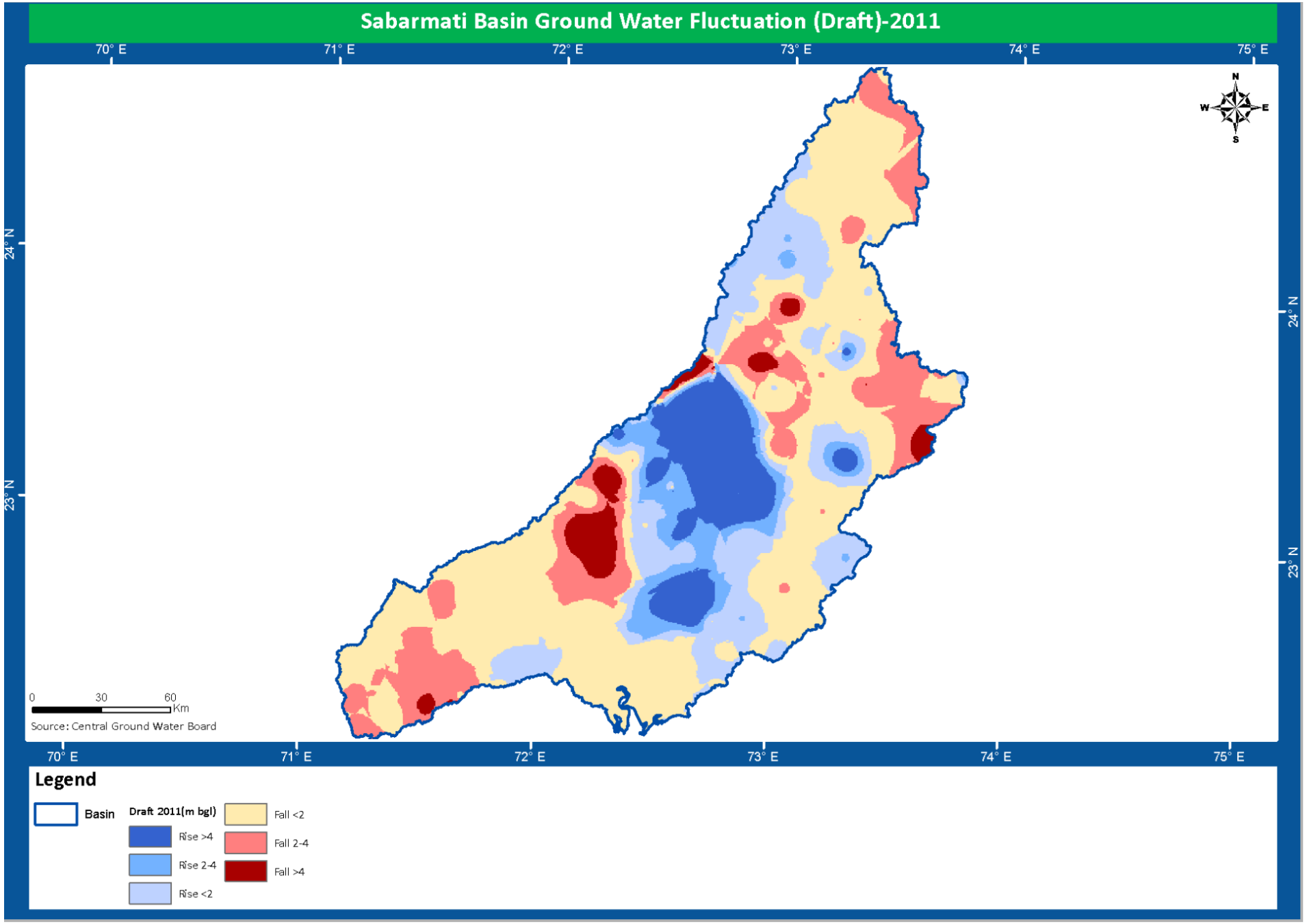
A comparatively low value in the water level rise (< 2 m) is indicated in parts of Ahmedabad, Gandhinagar and Anand districts of Gujarat falling in the basin. However, very small portions of Gandhinagar, Kheda and Sabarkantha also shows a fall of 2 - 4 m.

Ground water fluctuation maps due to draft (2011) shown in Map 20 which shows a Ground water fall of < 2 m in a large part of the basin. Some parts of the districts like Ahmedabad, Gandhinagar, Bhavnagar, Panchmahal, Sabarkantha, Kheda and Dungarpur also show a fall of 2 - 4 m. Ahmedabad Sabarkantha and Panchmahal showing a fall of > 4 m in some areas.

However, some areas of Gandhinagar, Sabarkantha, Mehsana and Banaskantha districts shows a rise of 2 - 4 m.



Map 19. Ground water level fluctuation (Recharge)



Map 20. Ground water level fluctuation (Draft)

4.3 Litholog well locations

An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which Ground water can be extracted using a dug well or bore well. Related terms include an aquitard, which is a bed of low permeability along an aquifer and aquiclude, which is a solid, impermeable area underlying or overlying an aquifer. If the impermeable layer overlies the aquifer layer, pressure could cause it to become a confined aquifer. Aquifers may occur at various depths. Those closer to the surface are not only more likely to be used for water supply and irrigation, but are also more likely to be tapped up by the local rainfall. Alluvium, sandstone, loose sand/gravel etc. are the better aquifer material. In hard rock areas, fracture/lineament plays an important role in identifying Ground water potential areas. The information on the aquifer material, depth and thickness of the aquifer layers in a basin can be analyzed based on the available litholog information.

Due to lack of lithology data in this basin, the exact aquifer material in this basin could not be ascertained.However, in the northern part of the basin, including areas in Rajasthan and those in Sabarkantha district the aquifers available are highly jointed and fractured or extensively weathered rock zones. Wells tapping from thick rock-formations of this type yield as much as 1,00,000 litres per hour though 40,000 litres per hour would be more common. Such aquifer of moderate potential is available within 100-150 m below ground level and even as close as 30-40 m depth if one was especially fortunate. The parts of the basin in Kheda and Surendranagar district have only limited Ground water potentials comparable to that in northern parts of the basin and good confined aquifers are not available. The Phreatic aquifers in the alluvial strata are only suited for shallow wells and low yields tube wells.

5. Hydro-met observations

Meteorology and hydrology compose the interdisciplinary field of hydrometeorology. Systematic and scientific hydrological observation and other water resources data collection forms the basic need in the rational assessments of the surface water resources of river basins, which is one of the foremost inputs for the overall planning and development of the basin.

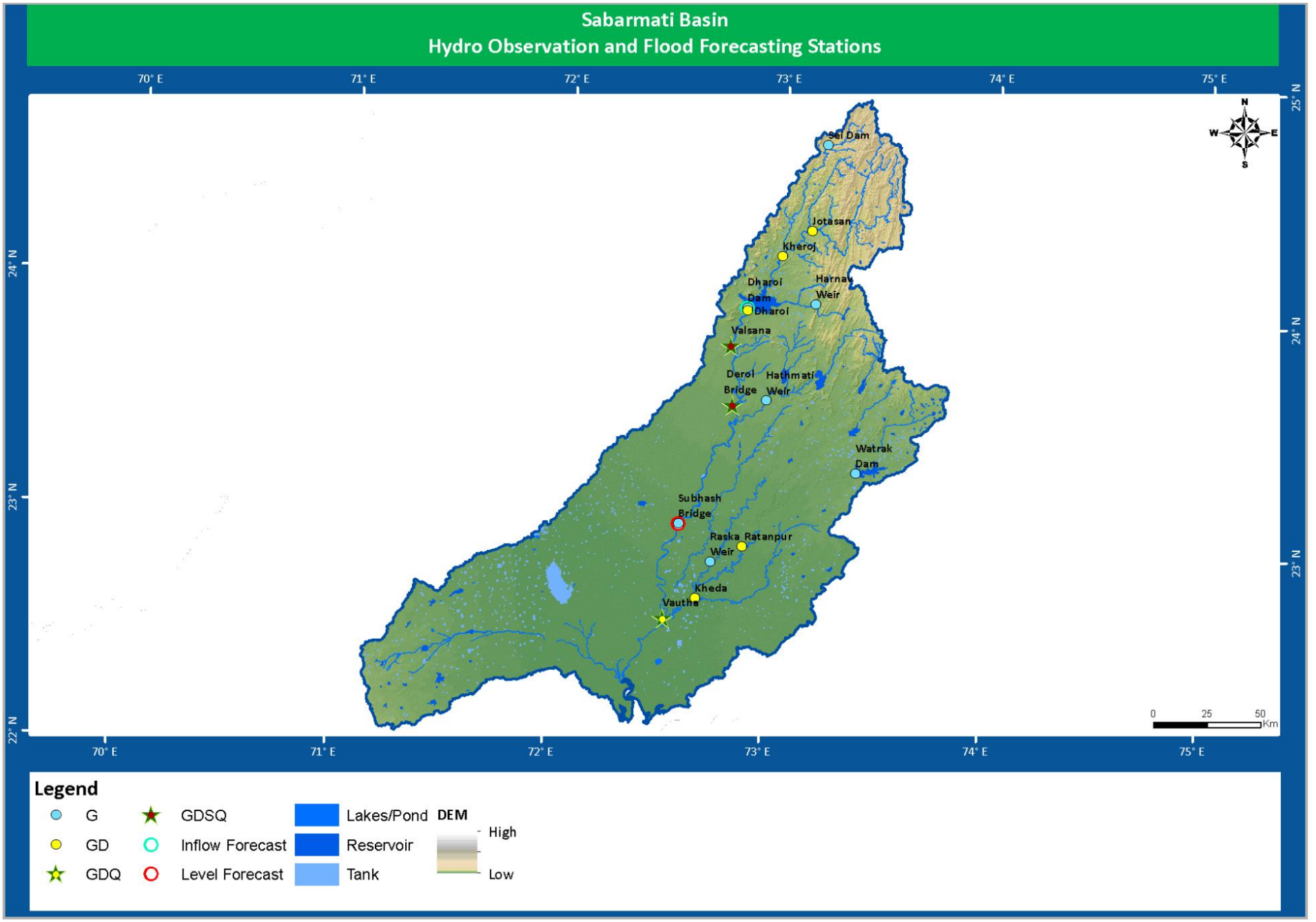
5.1 Hydrological observation sites

The Central Water Commission maintains 15 Hydro observations sites in the Sabarmati basin. These HO stations carry out observations about various hydrological parameters as gauge (river water level), discharge (amount of water released from a cross section in the river in a given time period), sediment (concentration of solid particles in water) and river water quality pertaining to different quality parameters. Some of the H.O sites also measure various climatic parameters. In addition to these sites some of the sites are directly engage for flood forecasting activities. The spatial distribution of the Hydro-observation stations are shown in the Map 21.

Fifteen Hydro-observation stations of CWC are located in the basin (Map 21).These stations are categorized as 'GDSQ', where the abbreviation stands as: G-Gauge, D-Discharge, S-Sediment and Q-Water Quality. RF stands for rainfall measuring station. Hydrological observations are carried out by the central as well as state Governments. There are 7 Gauge Sites, 5 Gauge Discharge Sites, 1 gauge discharge quality sites and 2 gauge discharge sediment quality sites are maintained by CWC for the study of hydrological observations in Sabarmati basin as shown in Table 10.

Table 10. Hydrological observation sites of CWC

Sl. No.	Station Type	Number of Stations
1	G	7
2	GD	5
3	GDQ	1
4	GDSQ	2



Map 21. Hydro observation and flood forecasting stations

5.2 Flood forecasting sites

Flood causes considerable damage to human lives and property almost every year. Since adoption of National Flood Policy by Government of India in 1954, it was realized that a total protection against flood by structural means alone is not possible and that optimum solution would consist of a mixture of structural and non-structural measures. Therefore, stress has been laid on non-structural measures like flood forecasting and warning, which is most important among such means to minimize the damage potential from floods.

Central Water Commission, Ministry of Water Resources has set up a network of flood forecasting stations covering all important flood prone rivers. Flood forecasting indicates the forecast or inflow level with its time of occurrence. Two kinds of forecasts are issued based on the utility of the forecast. Inflow forecasts assist in reservoir regulation (full reservoir level and maximum water level) and the level forecast is used for predicting water level (warning level and danger level) well ahead of its occurrence.

The Sabarmati basin has two Flood forecasting stations of CWC in the Sabarmati basin (Map 21), namely, Dharoi dam (Level forecast) and Subash Bridge, Ahmedabad (Inflow forecast). These stations are wireless capable for quick releasing of warning info during flood situation. The detail of Flood forecasting stations is given in Annexure: V B. The types of flood forecasting stations of CWC are given in Table 11.

Table 11. Types of flood forecasting stations of CWC

Sl. No.	Station Type	Number of Stations
1	Level Forecast	1
2	Inflow Forecast	1

5.3 Meteorological stations

CWC has established 13 Hydro-meteorology stations in the basin having meteorological capabilities. These stations are established to understand the relationship between meteorological parameter and river dynamics. The basin has 39 Indian Meteorological stations (IMD). The detail of salient features of Hydro- meteorological stations is given in Annexure: V A.

Under the supervision of ISRO there are 10 AWS station are established in the basin. These stations are maintained and data stored by the MOSDAC. Refer Table 12 for details.

Table 12. Meteorological stations

Sl. No.	Organization	Number of Stations
1	CWC Observation Stations	13
2	IMD Stations	39
3	ISRO AWS Stations	10

6. Water quality

6.1 Surface water quality observations

The quality of surface water is being monitored in the country since several decades by various agencies viz. the Central Water Commission (CWC), the State Irrigation Departments and the Central and State Pollution Control Boards. However, the mandates and objectives of these agencies are being different, there had been no unified procedure for monitoring to provide a holistic view of the characteristics of the Waterbodies. While the interest of the CWC was mostly oriented towards the development of the surface water resources, the river gauging and discharge measurement and determination of sediment transport and its characteristics at limited locations, the water quality was analyzed for a few

The state water resources agencies also were confined to similar activities, but their main interest was devoted to the determination of the suitability of the surface water resources for use in irrigation. The interest of the Pollution Control Boards were limited to determination of the health of the river in terms of pollution related parameters for surveillance of water quality and determination of impact due to discharge of pollutants through different sources

Observation stations to provide information on water quality of surface Waterbodies, viz., rivers, lakes, etc. are maintained in the country by two apex organizations namely, Central Water Commission (CWC) and Central Pollution Control Board (CPCB).CWC stations carry out observations for testing the surface water quality pertaining to 68 water quality parameters which are considered to be the 'Standard Hydrology Project Water Quality Parameters'. All physical, chemical and biological water quality parameters are categorized further under sub categories like field determinations, nutrients, organic matter, alkalinity, hardness, other inorganic, major ions, coliforms and others.

The Central Water Commission is supplementing the activities of water quality assessment by monitoring water quality at 3 sites located on the major rivers of Sabarmati basin. These surface water quality stations located at the river site for periodically monitoring of water quality. These stations are established by CWC and their data were analyzed at CWC water quality labs located at various places of the India. Water quality observations are taken at 3 sites of CWC, namely Derol Bridge, Valsana and Vautha. Generally the Waterbodies in the basin provide water suitable for irrigation, fisheries and water supply.

In particular, at Ahmedabad, the river is more or less like a drain. The flow is very small during the summer months. Sabarmati River is notorious for being almost depleted of dissolved oxygen during summer or pre-monsoon months. However, the situation has improved after the Narmada canal has started supplying water to some places in the basin due to dilution effect. It is also a matter of concern that at some places.

6.2 Ground water quality observations

There are 22 Ground water quality stations of CGWB in Sabarmati basin. The Ground water quality at observation wells located in the Sabarmati basin is measured on the basis of main 15 parameters which include values for Magnesium, pH, Nitrate, Potassium, Sulphate, Electrical Conductivity (EC), Total Dissolved Solids (TDS) , Calcium, Sodium, Carbonate, Bicarbonate, Chloride, Fluoride, Sodium Absorption Ratio(SAR), Residual Sodium Carbonate(RSC), Arsenic and Iron which are specific to areas. They are further classified in two categories viz. Irrigation and Drinking water quality standards as described by Bureau of Indian Standards (BIS) for Ground water quality.

As per studies about Ground water potential has been made in parts of Mehsana, Sabarkantha, Ahmedabad and Kaira districts of Sabarmati basin. Observations in Mehsana district indicate that the quality of Ground water deteriorates progressively from east to west. Sabarkantha district is underlain by Precambrian crystalline rocks, Himatnagar sandstones, lava flows alluvium and blown sand. The depth of the water-table varies from 2 to 20 m, except in the area lying between the rivers Sabarmati and Bokh where it goes down to as much as 35 m. The water is of good quality and the feasibility of tapping the sandstones in selected parts has been confirmed.

In the area south of Ahmedabad, water-table lies at a depth between 10 to 20 meters. The quality of the near-surface Ground water is generally good. The depth of water-table over large parts of Watrak area ranges from 10 to 25 m, except in the vicinity of the Watrak river where it is about 10 m in depth. In this part, the quality of water improves with the depth. Due to artesian water in Kaira and Mehsana districts, abnormally high temperatures of water at depths of over 200 m will have to be taken into account before considering its fitness for direct application to irrigation. These temperatures are too high for plant tolerance. (Source: Irrigation Commission Report-1972)

7. Inter basin transfer links

Inter basin transfer link proposes river water transfer from the region of surplus to deficit areas and provide an effective ways to enhance irrigation potential, to mitigate floods and droughts and reduce regional imbalance by way of additional irrigation, domestic and industrial water supply, hydropower generation and navigational facilities etc.

NWDA has proposed 30 possible links in India which include 14 Himalayan components and 16 peninsular components. One of those 14 Himalayan links, are proposed to connecting the Sabarmati River/ tributaries to Sabarmati basin. These links are shown in Map 22.

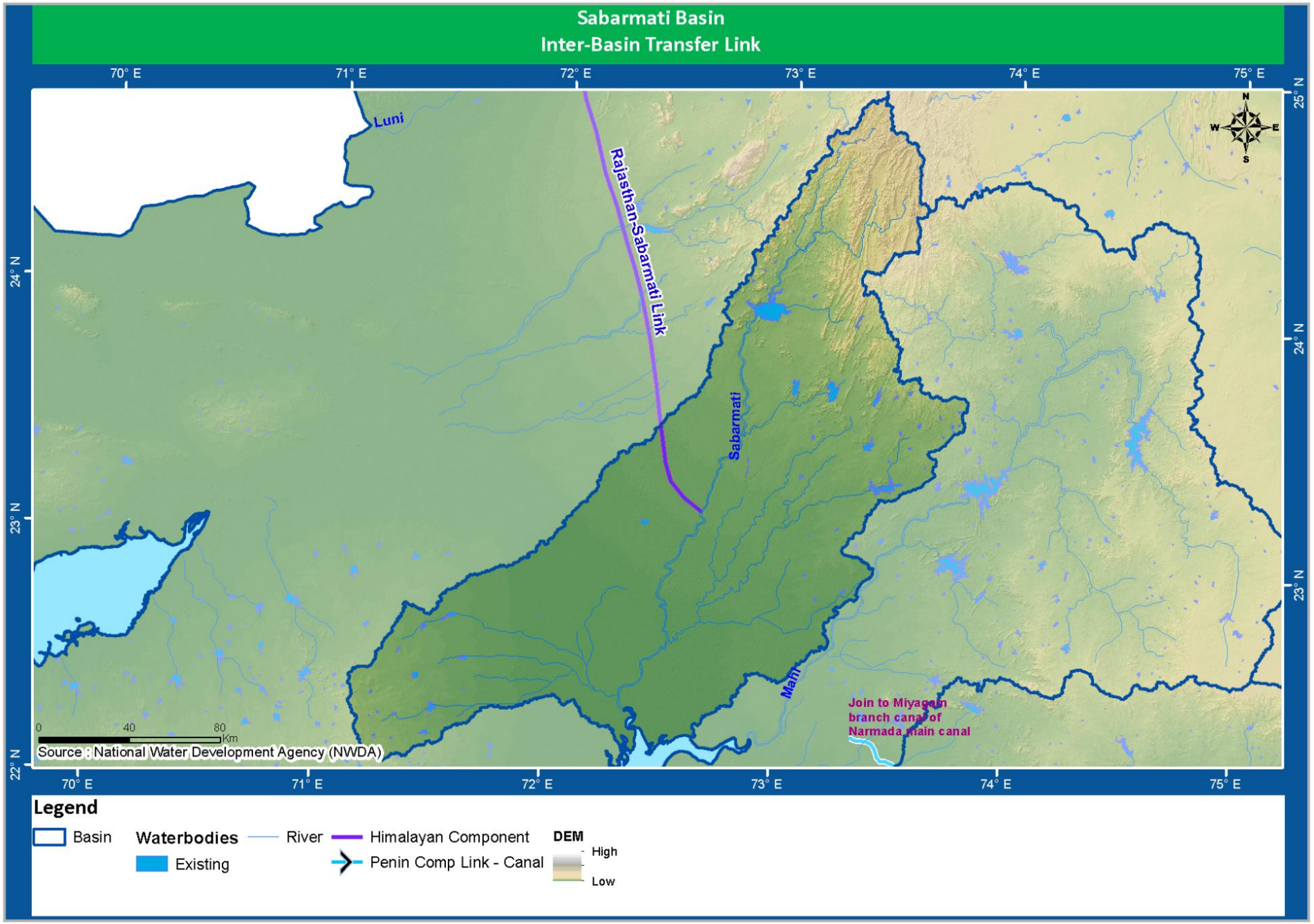
Rajasthan-Sabarmati Link Project

There are two important inter-basin transfer links made /proposed in the basin. The Rajasthan-Sabarmati link canal is an extension of the proposed Yamuna-Rajasthan Link (Map 22). The link envisages a transfer of 5,924 Mcum water available at the tail end of the Yamuna-Rajasthan link for drought prone areas of Rajasthan and Gujarat. The length of the canal is about 725 km out of which 650 km lies in Rajasthan and the rest 75 km in Gujarat. The design discharge at the head and the tail are 344 cumec and 60 cumec, respectively. The full supply depth and bed width of the canal at its head are 6 m and 39 m, respectively.

The Rajasthan-Sabarmati link canal on its way will cross the Luni River and its tributaries and the Banas River. The Rajasthan-Sabarmati link will provide an annual irrigation of 535,000 ha in the districts of Jaisalmer, Barmer and Jalor districts of Rajasthan. The total annual irrigation thus envisaged in Rajasthan state through the above two inter-basin water transfer links works out to be 779,200 Ha.

Further, interlinking the Gandak, the Ghagra, the Sarda and the Yamuna, all tributaries of the Ganga, on to Rajasthan, the link aims at transferring the waters of Gandak and Ghagra rivers to benefit areas in Uttar Pradesh, Uttarakhand, Haryana, Rajasthan, Gujarat, Bihar and Jharkhand. Other important links proposed in the Himalayan component are the Kosi - Ghagra, Gandak - Ganga, Ghagra - Yamuna and Sarda-Yamuna links to supplement the supplies of the Ganga and the Yamuna and for further transfer of water towards the west to Rajasthan and Gujarat. A large canal parallel and to the east of the existing Rajasthan canal is proposed which will be extended beyond the tail of the present Rajasthan canal and be linked to the Sabarmati. (Source: National Institute of Hydrology, Roorkee)

Rajasthan Sabarmati link is present in this basin. The link connects Sukri River and Sabarmati River. The orientation of the link suggests the proposed command of the link covers Gandhinagar, Mahesana, Patanand Banaskantha districts of Gujarat and Jalor, Barmer and Jaiselmer districts of Rajasthan.



Map 22. Inter basin transfer links

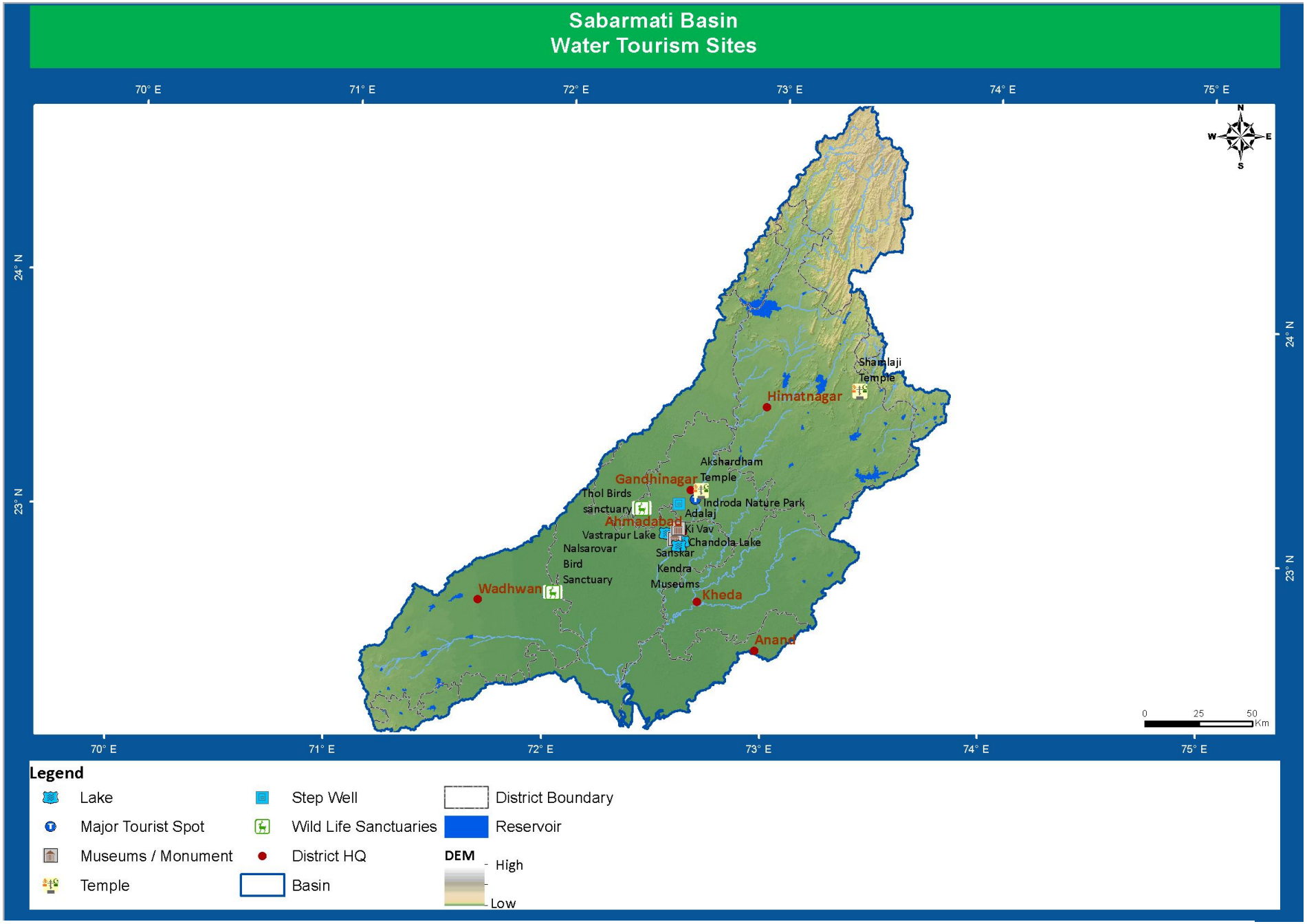
8. Water tourism sites

There are a total of 11 major water tourism places in the basin. These include National parks, Lake, Step Well, Museums, Pilgrimages and waterfall, etc. The categorization and account of water tourism sites is given in Table 13.

Sabarmati basin hosts a rich environment for water tourism sites. Gujarat is the only home of Asiatic lions and outside Africa, Gujarat is the only present natural habitat of lions. Gir Forest National Park in the southwest part of the state covers part of the lion's habitat. Apart from lions, leopards are also found in state. They are spread across the large plains of Saurashtra and the mountains of South Gujarat. Other National parks include Vansda National Park, Blackbuck National Park, Velavadar and Narara Marine National Park, Gulf of Kutch, Jamnagar. Wildlife sanctuaries include: Nal Sarovar Bird Sanctuary, Porbandar Bird Sanctuary, Kutch Desert Wildlife Sanctuary, Kutch Bustard Sanctuary, Narayan Sarovar Sanctuary, Jessore Sloth Bear Sanctuary, Anjal, Balaram-Ambaji, Barda, Jambughoda Wildlife Sanctuary, Khavda, Paniya, Purna, Rampura, Ratanmahal, and Surpaneshwar. Gujarat has some of major mountain ranges of India, including Aravalli, Sahyadri (Western Ghats), Vindhya and Saputara. Apart from this Gir hills, Barda, Jessore, Chotila, etc. are situated in different parts of Gujarat. Girnar is the tallest peak and Saputara is the only hill-station in the state. Saputara is perched at an altitude of 1000 m, and is situated in the heart of Dangs district. Nearby Surat city, it is located on the second highest plateau of the Sahyadari range with cool bracing climate and a scenic view of the verdant valley. Sabarmati Ashram is the place where Gandhi initiated Dandi March. Spatial Distribution of Water Tourism Sites/Important district center/industrial Centre in the Basin is shown in the Map 23.The detail of water tourism sites is given in Annexure: VI A.

Table 13. Water tourism sites

Sl. No.	Tourist Site Category	No. of Places
1	Wild Life Sanctuaries	2
2	Lake	3
3	Step Well	1
4	Museums / Monument	2
5	Major Tourist Spot	1
6	Pilgrimage (Temple)	2



Map 23. Water tourism sites

9. Conclusion

The Sabarmati basin is bounded by Aravalli hills in the north and north-east, Rann of Kutch in the west and Gulf of Khambhat in the south. The terrain of Sabarmati basin is hilly in the early reaches up to Dharoi after which the river flows mostly in plains. The northern part of the basin is marked by hilly terrain while the southern part has large alluvium plain having gentle slope. The dominant crops harvested in the basin depend largely on the season and availability of water.

The monsoon is the main cultivation season. The Sabarmati basin constitute of two major sub basins: - Sabarmati upper sub basin and Sabarmati lower sub basin.

Mean annual rainfall in the basin accounts to 689.90mm. The utilizable surface water resources in Sabarmati basin is 1.9 BCM. The total live storage capacity is 1.45 BCM (completed- 1.30 BCM, Under-construction- 0.06 BCM and under –consideration- 0.09 BCM) (Source: WM Directorate, CWC). Hence, 9.57 BCM water potential can be utilized further for developments in the basin.

The water resources of the Sabarmati basin are well developed. As a part of water resources projects in the basin, there are 50 dams, 2 barrages, 10 weirs, 40 command areas and 20 major medium irrigation projects in the basin.

Due to lack of lithology data in this basin, the exact aquifer material in this basin could not be ascertained.However, In the northern part of the basin, including areas in Rajasthan and those in Sabarkantha district the aquifers available are the highly jointed and fractured or extensively weathered rock zones.

The economy of the basin largely depends on agriculture and forest. The industrial development in the basin has taken place mainly in the lower part of the basin. The middle and lower parts of the basin are well served with communications, whereas the upper part lacks communication facilities.

There is need for inter-State co-operation and agreement in respect of carrying out soil conservation measures and conserving the storage capacities of existing and proposed reservoirs in the basin.

Systematic and scientific exploratory work is needed for a quantitative and qualitative assessment of the Ground water resources in the basin, so that these resources can be exploited in a rational way either independently or in conjunction with surface waters.

Annexure I: State, district and parliamentary constituency in the basin

A. District Details						
Sl. No.	State Name	District (2011)	Population (2011)	Total Area (Sq. Km)	District Area in Basin (Sq. Km)	% of District Area in the Basin
1	Gujarat	Ahmedabad	7214225	7712.66	4718.07	61.17
2	Gujarat	Anand	2092745	2806.43	1785.66	63.63
3	Gujarat	Surendranagar	1756268	10116.24	4603.36	45.50
4	Gujarat	Sabarkantha	2428589	7140.29	7113.86	99.63
5	Gujarat	Rajkot	3804558	10762.12	261.22	2.43
6	Gujarat	Banaskantha	3120506	10247.55	506.28	4.94
7	Gujarat	Bhavnagar	2880365	8062.74	213.25	2.64
8	Gujarat	Gandhinagar	1391753	2055.07	2055.07	100
9	Gujarat	Kheda	2299885	3843.53	3325.40	86.52
10	Gujarat	Mahesana	2035064	4244.35	2087.36	49.18
11	Gujarat	Panchmahal	2390776	5095.62	68.67	1.35
12	Rajasthan	Dungarpur	1388552	3640.43	597.87	16.42
13	Rajasthan	Sirohi	1036346	4961.34	54.66	1.10
14	Rajasthan	Udaipur	3068420	11459.12	3289.85	28.71

Source : Survey of India and Census Data, 2011

Note: Population is mentioned for the whole district

B. Parliamentary Constituency Details					
Sl. No.	State Name	Parliamentary Constituencies (2009)	Total Area (Sq. Km)	Area Falling in Basin (Sq. Km)	% Area in the Basin
1	Gujarat	Sabarkantha	7140.29	7113.85	99.63
2	Gujarat	Bhavnagar	6364.84	213.25	3.35
3	Gujarat	Mahesana	3890.89	2172.72	55.84
4	Gujarat	Banaskantha	8449.51	506.28	5.99
5	Gujarat	Patan	8072.49	403.52	5
6	Gujarat	Panchmahal	5016.78	1101.81	21.96
7	Gujarat	Ahmedabad (East)	1137.55	1137.55	100
8	Gujarat	Rajkot	6093.73	275.28	4.52
9	Gujarat	Kheda	3913.69	3913.69	100
10	Gujarat	Surendranagar	14472.36	5927.56	40.96
11	Gujarat	Ahmedabad (West)	196.71	196.71	100
12	Gujarat	Anand	2786.96	1779.93	63.87
13	Gujarat	Gandhinagar	1996.03	1996.03	100
14	Rajasthan	Banswara	7438.97	602.85	8.10
15	Rajasthan	Udaipur	11034.48	3276.29	29.69
16	Rajasthan	Jalore	15301.21	63.24	0.41

Source: Election Commission of India

Annexure II : Climate – Rainfall (1971-2004) and Temperature (1969-2004) profile in the basin

A. Sub-Basin Wise Annual Rainfall (mm) (1971-2004)			
Sl. No.	Year	Annual Rainfall	
		Sabarmati Lower Sub Basin	Sabarmati Upper Sub Basin
1	1971	500.4	558.05
2	1972	263.28	388.96
3	1973	641.39	1172.02
4	1974	258.94	323.45
5	1975	1036.99	1086.62
6	1976	1161.3	1317.56
7	1977	871.31	1076.08
8	1978	631.9	947.86
9	1979	864.08	666.1
10	1980	598.65	677.36
11	1981	832.05	859.85
12	1982	561.35	608.1
13	1983	828.46	962.25
14	1984	614.79	682.03
15	1985	403.14	448.92
16	1986	299.45	301.79
17	1987	197.97	287.45
18	1988	887.28	828.9
19	1989	561.72	644.01
20	1990	798.68	1080.88
21	1991	353.01	509.38
22	1992	546.97	691.28
23	1993	593.94	684.67
24	1994	973.88	1206.52
25	1995	476.46	548.84
26	1996	541.02	755.12
27	1997	788.03	1025.07
28	1998	775.87	881.17
29	1999	467.71	517.31
30	2000	557.38	511.46
31	2001	683.7	688.79
32	2002	348.14	437.8
33	2003	745.37	838.72
34	2004	667.54	672.61

B. Temperature profile in the basin (36 Years Average for the period 1969-2004)				
Sl. No.	**Month**	**Maximum Temperature (°C)**	**Minimum Temperature (°C)**	**Mean Temperature (°C)**
1	January	27.12	10.95	19.04
2	February	31.28	15.2	23.24
3	March	34.4	17.82	26.11
4	April	38.02	22.33	30.18
5	May	39.33	25.31	32.32
6	June	36.81	25.92	31.36
7	July	32.25	24.63	28.44
8	August	30.83	23.76	27.3
9	September	32.76	23.05	27.9
10	October	34.77	20.49	27.63
11	November	31.92	15.92	23.92
12	December	28.6	12.16	20.38

Source: IMD

Annexure III : Sub basin wise population and drinking water facilities

A. Demographic Details							
Sl. No.	Sub Basin	No. of Districts	No. Villages	Total Population	Male Population	Female Population	No. of Households
1	Sabarmati Lower Sub Basin	7	1092	2851994	1485444	1366550	555670
2	Sabarmati Upper Sub Basin	13	3628	10455256	5462602	4992654	2039866

Source: Census Data 2001

B. Drinking Water Facilities					
Sl. No.	Sub Basin	District	Wells	Tubewells	Handpumps
1	Sabarmati Lower Sub Basin	Anand	255	202	208
2	Sabarmati Lower Sub Basin	Rajkot	774	79	715
3	Sabarmati Lower Sub Basin	Ahmedabad	-	-	-
4	Sabarmati Lower Sub Basin	Bhavnagar	688	88	661
5	Sabarmati Lower Sub Basin	Surendranagar	388	212	300
6	Sabarmati Lower Sub Basin	Mahesana	161	523	25
7	Sabarmati Lower Sub Basin	Gandhinagar	26	256	40
8	Sabarmati Upper Sub Basin	Anand	255	202	208
9	Sabarmati Upper Sub Basin	Ahmedabad	-	-	-
10	Sabarmati Upper Sub Basin	Banaskantha	605	697	362
11	Sabarmati Upper Sub Basin	Dungarpur	660	207	659
12	Sabarmati Upper Sub Basin	Udaipur	1813	365	1830
13	Sabarmati Upper Sub Basin	Surendranagar	388	212	300
14	Sabarmati Upper Sub Basin	Sirohi	364	65	369
15	Sabarmati Upper Sub Basin	Mahesana	161	523	25
16	Sabarmati Upper Sub Basin	Panchmahal	-	-	-
17	Sabarmati Upper Sub Basin	Sabarkantha	1149	352	1161
18	Sabarmati Upper Sub Basin	Gandhinagar	26	256	40
19	Sabarmati Upper Sub Basin	Kheda	462	216	451
20	Sabarmati Upper Sub Basin	Pali	608	254	580

Source: Census Data 2001

Annexure IV : Inventory of surface water resources

A. List of Dams with surrogate information												
Sl. No.	Name of Dam	River	Type of Dam	Year of completion	Catchment Area (Sq. Km.)	Length of dam (m)	Max height above foundation (m)	Gross storage capacity	Live storage capacity (MCM)	Type of spillway	Submergence Area (Th Ha)	Purpose
1	Bodi Dam	Local Vangha	Earthen	1980	-	240	15	0.17	0.17	-	-	IR
2	Bhanmer Dam	Bhanmervangha	Earthen	1986	-	510	10	0.42	0.39	-	-	IR
3	Bhogavo-II (Wadhowan) Dam	Bhogavo	Earthen	1959	-	3891	39	20.4	18.69	-	0.91	IR
4	Borsi Dam	Chuli	Earthen	1969	-	565	17	2.17	1.81	-	-	IR
5	Chachka Dam	Magadakivehla	Earthen	1976	-	446	11	2.6	1.94	-	-	IR
6	Dhari Dam	Sukhbhadar	Earthen/ Gravity/ Masonry	1972	64.23	909	29.28	3.4	2.78	-	-	IR
7	Godechi Dam	T/Sukhbhadar	Earthen	1976	-	685	14	1.91	1.66	-	-	IR
8	Goma Dam	Goma	Earthen	1972	155.4	3083.48	20.87	26.11	24.59	Ogee	0.96	IR
9	Guhai Dam	Guhai	-	1990	422.17	3380	43.07	62.3	57	Ogee	1.53	IR
10	Harnav II Dam	Harnav	Earthen	1990	90.4	405	41.65	21.67	19.97	Ogee	0.31	IR
11	Hathmati Dam	Hatmati	Earthen	1989	594.95	993	23.62	152.83	148.93	Ogee	3.24	IR
12	Kakari Mahudi Dam	Kotar	Earthen	1976	-	810	13.97	0.69	0.61	-	-	IR

Sl. No.	Name of Dam	River	Type of Dam	Year of completion	Catchment Area (Sq. Km.)	Length of dam (m)	Max height above foundation (m)	Gross storage capacity (MCM)	Live storage capacity (MCM)	Type of spillway	Submergence Area (Th Ha)	Purpose
13	Karol(Baugh) Dam	Bokh	Earthen /Gravity / Masonry	1956	20	726	13.14	8.33	8.33	-	-	IR
14	Khedava Dam	Khosambi	-	2010	86.76	-	28	-	-	Ogee	0.18	IR
15	Kojan Dam	Local Wanga	Earthen	1988	-	3700	21	3.32	3.12	-	-	IR
16	Kundol Dam	Kundolvaga	Earthen	1962	-	320	11	1.43	1.42	-	-	IR
17	Lakhia Dam	Wangha	Earthen	1987	-	173	17.5	0.37	0.27	-	-	IR
18	Lank Dam	Ghelo	Earthen	-	-	72	10	1.46	1.3	-	-	IR
19	LimdiBhogavo I (Thorali) Dam	Bhogavo	Earthen / Gravity / Masonry	1962	612.94	2744	42.68	22.48	21.97	Chute	0.85	IR
20	Limdi-Bhogavo II Dam	-	Gravity / Masonry	1997	612.94	8806	19.87	15.17	13	-	0.63	IR
21	Limla Dam	Khari	Earthen	1912	-	427	15	8.35	8.35	-	0.17	IR
22	Maneknath Dam	T Of Sabarmati	Earthen	1990	-	260	15.1	0.31	0.27	-	-	-
23	Mazam Dam	Mazam	Earthen	1984	407.8	2402	28.75	43.9	36.6	Ogee	1.24	FC,IR

Sl. No.	Name of Dam	River	Type of Dam	Year of completion	Catchment Area (Sq. Km.)	Length of dam (m)	Max height above foundation (m)	Gross storage capacity (MCM)	Live storage capacity (MCM)	Type of spillway	Submergence Area (Th Ha)	Purpose
24	MeshwoDam	Meshwo	Earthen	1971	259	167.14	14.32	82	77	Other	1.12	FC,IR
25	Mevasa Dam	Dudnala	Earthen	-	-	3284	24	3.25	2.65	-	-	IR
26	Morsal Dam	Dundhala	Earthen / Gravity / Masonry	1999	-	3260	23.94	3.25	3.05	-	-	IR
27	Mota-Chhaida Dam	Sodhedare	Earthen	1995	-	842.5	11.5	0.61	0.61	-	-	IR
28	MotaKanthariya Dam	Local Wangha	Earthen	1981	-	939	13.39	0.28	0.28	-	-	IR
29	Motakotada Dam	Local Vangha	Earthen	1980	-	695	18	3.27	3.07	-	-	IR
30	Mulbavla Dam	Local Stream	Earthen	1977	-	9735	11.5	6.02	4.84	-	-	IR
31	Nanamatra Dam	Triveni	Earthen	1974	-	616	17	2.24	1.96	-	-	IR
32	Navabhetali Dam	Local vangha	Gravity / Masonry	1981	-	25	15	0.28	0.28	-	-	IR

Sl. No.	Name of Dam	River	Type of Dam	Year of completion	Catchment Area (Sq. Km.)	Length of dam (m)	Max height above foundation (m)	Gross storage capacity (MCM)	Live storage capacity (MCM)	Type of spillway	Submergence Area (Th Ha)	Purpose
33	Nayka(W-Bhogavo I) Dam	Bhogavo	Earthen	1959	-	2683	20.3	7.37	5.27	-	0.55	IR
34	Pith Gajipur Dam	T of Sabarmati	Earthen	1983	-	370	20	1.89	1.73	-	-	IR
35	Raniporda Dam	Vehla	Earthen	1948	-	1640	11	1.75	1.73	-	-	IR
36	Revania Dam	Goma	Earthen	1882	-	554	10	2.18	2.18	-	-	IR
37	Sabarmati Dam	Sabarmati	Earthen / Gravity / Masonry	1982	5539.98	1207	46	90.79	90.79	Ogee	-	IR, WS
38	Saburi Dam	T/Vartu	Earthen / Gravity / Masonry	2002	-	2400	11.35	-	-	-	-	IR
39	Savli Dam	Local Stream	Earthen	1910	-	2301	11	4.88	4.88	-	-	IR
40	Sei Diversion Dam	Sei	Earthen / Gravity / Masonry	1978	-	1453	28	31.33	25.82	-	2.93	IR
41	Solsandha Dam	T of Banas	Earthen	1935	-	325	17	1.53	1.03	-	-	IR

Sl. No.	Name of Dam	River	Type of Dam	Year of completion	Catchment Area (Sq. Km.)	Length of dam (m)	Max height above foundation (m)	Gross storage capacity (MCM)	Live storage capacity (MCM)	Type of spillway	Submergence Area (Th Ha)	Purpose
42	Sukhbhadar Dam	Sukhbhadar	Earthen / Gravity / Masonry	1987	489	1167.55	13	-	-	Ogee	0.84	FC,IR
43	Thol Dam	-	-	-	-	-	-	-	-	-	-	
44	Umri Dam	T/Sabarmati	Earthen	1963	-	154	17	1.51	1.37	-	-	IR
45	Vagadi Dam	Local Vangha	Earthen	1985	-	470	17.5	1	0.89	-	-	IR
46	Vagas Dam	Vehla	Earthen	1978	-	3414	10	1.02	0.94	-	-	IR
47	Vagdokyari Dam		Earthen	1984	-	158	17	1.14	1.01	-	-	IR
48	Vaidy Dam	Watrak	Earthen	1980	56	1008	19.1	13.6	12.27	-	-	IR
49	Virpur Dam	Virpurvangha	Earthen	1980	-	778	15	0.47	0.44	-	-	IR
50	Watrak Dam	Watrak	Earthen	1983	11140	325	43.31	176.2	154.4	Ogee	4.39	IR

B. List of BWA with surrogate information							
Sl. No.	**Name of B/W/A**	**River**	**Length (m)**	**Height upto crest (m)**	**Catchment area (Th. ha.)**	**Design flood discharge (Cumecs)**	**Purpose**
1	Mohar Weir	Sabarmati	-	-	-	1200	IR
2	Harnav Weir	Harnav	201.17	-	400	2405.5	IR
3	Hathmathi Weir	Hathmati	230	-	-	2943.2	IR
4	Kenyta Weir	Harnav	-	-	-	-	IR
5	Lakroda Weir	Sabarmati	-	-	-	-	IR
6	Mamerchi Weir	Harnav	-	-	-	-	IR
7	Moti Fatehwadi Weir	Sabarmati	-	-	-	-	FC,IR
8	Raipur Weir	Khari	61.87	-	-	934	IR
9	Raska Weir	Meshwa	166.12	-	-	2286	IR
10	Sabarmati Weir (Vatamam)	Sabarmati	-	-	-	-	IR
11	Varanai Barrage	-	1544	3	-	352.4	IR
12	Wasna Barrage	Sabarmati	610.51	20.75	11	21000	IR

C. Major/Medium irrigation projects with surrogate information										
Sl. No.	**Name of Project**	**Type**	**River**	**Tributary**	**Status**	**Year of completion**	**GCA (Th ha)**	**CCA (Th ha)**	**UIP (Th ha)**	**District/s Benefitted**
1	Bhogavo (Wadhovan) - I Medium Irrigation Project	Medium	Sabarmati	Bhogavo	Completed	-	-	3.24	-	Surendranagar

Sl. No.	Name of Project	Type	River	Tributary	Status	Year of completion	GCA (Th ha)	CCA (Th ha)	UIP (Th ha)	District/s Benefitted
2	Bhogavo (Wadhovan) - II Medium Irrigation Project	Medium	Sabarmati	Bhogavo	Completed	-	-	0.6	-	Surendranagar
3	Guhai Medium Irrigation Project	Medium	Sabarmati/Guhai	Guhai	Completed	1992	13.5	8.22	7.93	SabarKantha
4	Harnav - I Medium Irrigation Project	Medium	Sabarmati	Harnav	Completed	-	4.05	2.48	1.83	SabarKantha
5	Harnav - II Medium Irrigation Project	Medium	Sabarmati/Guhai	Harnav	Completed	1999	6.06	1.56	-	SabarKantha
6	Hathmati Major Irrigation Project	Major	Hathmati	Hathmati	Completed	1968	73.82	17.49	44.52	SabarKantha, Ahmedabad
7	Kharicut Canals Major Irrigation Project	Major	Khari	Sabarmati	Completed	-	24.28	14.61	8.1	Ahmedabad
8	LimbadiBhagavo Medium Irrigation Project	Medium	Sabarmati	Bhogavo	Completed	1997	5.43	4.2	4.65	Surendranagar
9	Limbdi - Bhogavo - II Medium Irrigation Project	Medium	Sabarmati/Bhagavo	Limdi-bhogavo	Ongoing	-	5.43	4.65	4.51	Surendranagar
10	Mahi Stage - I (Wanakbori) Major Irrigation Project	Major	Mahi	Mahi	Completed	1980	315.79	212.69	260	PanchMahals, Kheda

Sl. No.	Name of Project	Type	River	Tributary	Status	Year of completion	GCA (Th ha)	CCA (Th ha)	UIP (Th ha)	District/s Benefitted
11	Mazam Medium Irrigation Project	Medium	Sabarmati/Mazam	-	Completed	-	8	4.72	5.26	SabarKantha
12	Meshwa Major Irrigation Project	Major	Sabarmati	Meshwo	Completed	1971	-	16.27	6.88	SabarKantha, Ahmedabad
13	Meshwo Canal Major Irrigation Project	Major	-	Meshwo	Completed	-	-	9.11	10.32	-
14	Moti Fatewadi Major Irrigation Project	Major	West Flowing Rivers	Sabarmati	Completed	-	129.5	95.83	29.19	Ahmedabad
15	Sabarmati (Dharoi) Major Irrigation Project	Major	Sabarmati	Sabarmati	Completed	-	78.18	74.32	64	Mahesana, SabarKantha
16	Sai Medium Irrigation Project	Medium	Sei	Sei	Completed	1978	-	41.7	9.03	Udaipur
17	Sardar Sarovar Major Irrigation Project_Gujarat	Major	Narmada	Narmada	Ongoing	-	3428	2120	1792	Bharuch, Panchmahal, Ahmedabad, Gandhinagar, Mahesana, BanasKantha, Kutch, Vadodara, Rajkot, Bhavnagar, Surendranagar, SabarKantha
18	Vaidy Medium Irrigation Project	Medium	Sabarmati/Watrak	suron	Completed	-	-	2.01	-	SabarKantha

Sl. No.	Name of Project	Type	River	Tributary	Status	Year of completion	GCA (Th ha)	CCA (Th ha)	UIP (Th ha)	District/s Benefitted
19	Varanai Medium Irrigation Project	Medium	Sabarmati/Mehar	Mehar	Completed	-	-	1.83	1.81	Kheda
20	Watrak Major Irrigation Project	Major	Sabarmati	Watrak	Completed	2000	25.91	18.34	16.87	SabarKantha

Source: India-WRIS

D. ERM projects with surrogate information						
Sl. No.	**Name of Project**	**River**	**Status**	**Year of completion**	**Districts Benefitted**	**Purpose**
1	Ext of Dharoi of RBMC	Sabarmati	Ongoing	-	Mahesana, Patan, Gandhinagar, Surat	Irrigation
2	Hathmati Modernisation	Hathmati	-	-	SabarKantha	Irrigation
3	Modernisation of MotiFatewadi	Sabarmati	Completed	-	Ahmedabad	
4	Modernisation of Kharicut Canal	Khari	Completed	-	Ahmedabad	Irrigation

Annexure V : Salient features of hydro-meteorological stations

A. Salient features of Hydro-meteorological Stations										
Sl. No.	Station Name	Station type	Independent river	Regional office	Division	Section office	Drainage area (Sq. Km.)	Zero of Gauge (m)	Station bank	Status
1	Derol Bridge	GDSQ	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Derol Bridge	6724	87	Left	Existing
2	Dharoi	GD	Sabarmati	N & T BO, Gandhinagar	-	-	-	-	Right	Closed
3	Dharoi Dam	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Dharoi	5475	-	Right	Existing
4	Harnav Weir	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Harnav Weir	401	234.76	Left	Existing
5	Hathmati Weir	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Himatnagar	1357	134.05	Left	Existing
6	Jotasan	GD	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Jotasan	1421	285	Left	Existing
7	Kheda	GD	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Kheda	7550	19	Right	Existing
8	Kheroj	GD	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Kheroj	3650	208	Left	Existing
9	Raska Weir	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Raska Weir	1683	35.51	Right	Existing
10	Ratanpur	GD	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Ratanpur	2916	37	Left	Existing
11	Sei Dam	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Sei Dam	332	515.25	Left	Existing

Sl. No.	Station Name	Station type	Independent river	Regional office	Division	Section office	Drainage area (Sq. Km.)	Zero of Gauge (m)	Station bank	Status
12	Subhash Bridge	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Subhash Bridge	10674	41	Left	Existing
13	Valsana	GDSQ	Sabarmati	N & T BO, Gandhinagar	-	-	-	-	-	Closed
14	Vautha	GDQ	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Gandhinagar	Voutha	19636	12	Left	Existing
15	Watrak Dam	G	Sabarmati	N & T BO, Gandhinagar	Mahi Division, Ahmedabad	Watrak Dam	1114	128	Left	Existing

B. Salient features of Flood-Forecasting Stations

Sl. No.	Site Name	Met Sub Division	Independent river	Type of Forecast	Base Station-1	Travel Time Base Station-1 (hrs)	Base Station-2 (hrs)	Travel Time Base Station-2	Full Reservoir Level (m)	Max Reservoir Level (m)	Highest Flood Level (m)	Year of H.F.L	Mode of Collection
1	Dharoi Dam	Gujarat Reg. Daman and Diu and Nagar Havelli	Sabarmati	Inflow Forecast	Kheroj	2-5	Harnav Weir	2-5	187.45	192.25	189.63	1990	Wireless/ Telemetry
2	Subash Bridge (Ahmedabad)	Gujarat Reg. Daman and Diu and Nagar Havelli	Sabarmati	Level Forecast	Derol Bridge	4-6	Hatmati Weir	4-6	-	-	47.45	2006	Wireless/ Telemetry

Annexure VI : Inventory of water tourism sites

A. Water Tourism Sites in the Basin						
Sl. No.	**Name**	**Type**	**Waterbody**	**WB Relation**	**District**	**State**
1	Adalaj Ki Vav	Step Well	Adalaj Ki Vav	On	Gandhinagar	Gujarat
2	Akshardham Temple	Pilgrimage (Temple)	Sabarmati river	Near by	Gandhinagar	Gujarat
3	Chandola Lake	Lake	Chandola	On	Ahmedabad	Gujarat
4	Gandhi Ashram, Sabarmati	Museums / Monument	Sabarmati river	On	Ahmedabad	Gujarat
5	Indroda Nature Park	Major Tourist Spot	Sabarmati river	On	Gandhinagar	Gujarat
6	Kankaria Lake	Lake	Kankaria	On	Ahmedabad	Gujarat
7	Sanskar Kendra Museums	Museums / Monument	Sabarmati river	Near by	Ahmedabad	Gujarat
8	Shamlaji Temple	Pilgrimage (Temple)	Meshwo river	Near by	SabarKantha	Gujarat
9	Vastrapur Lake	Lake	Vastrapur lake	On	Ahmedabad	Gujarat

B. Wildlife Sanctuaries / National Parks in the Basin											
Sl. No.	**Name**	**Type**	**Waterbody**	**WB Relation**	**Nearest City**	**District**	**State**	**Year of Establishment**	**Mammals**	**Birds**	**Reptiles**
1	Nal sarovar Bird Sanctuary	Bird Sanctuary	Nal Sarovar	On	-	Surendranagar	Gujarat	-	-	-	-
2	Phulwari Ki Nal Sanctuary	-	Sei River	On	-	Udaipur	Rajasthan	-	-	-	-
3	Thol Birds sanctuary	Bird Sanctuary	Thol Lake	Near by	-	Mahesana	Gujarat	-	-	-	-

Acronyms

AEZ	Agro-Ecological Zones
AIA	Annual Irrigated Area
AIBP	Accelerated Irrigation Benefits Programme
APGCL	Assam Power Generation Corporation Limited
AWS	Automatic Weather Stations
B&BBO	Brahmaputra and Barak Basin Organization
BB	Brahmaputra Board
BCB	Bansagar Control Board
BCM	Billion Cubic Metre
BIS	Bureau of Indian Standards
BOD	Biological Oxygen Demand
BR	Balancing Reservoir
BRB	Betwa River Board
BWA	Barrage Weir Anicut
C&SRO	Cauvery and Southern Rivers Organization
CAZRI	Central Arid Zone Research Institute
CBIP	Central Board of Irrigation & Power
CCA	Culturable Command Area
CEA	Central Electricity Authority
CGWB	Central Ground water Board
Ch	Chainage
CIWTC	Central Inland Water Transport Corporation
CPCB	Central Pollution Control Board
CSMRS	Central Soil & Materials Research Station
cumec	cubic metre per sec
cusec	cubic foot per sec
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
D	Discharge
DEM	Digital Elevation Model
DOS	Department of Space
DVC	Damodar Valley Corporation
EC	Electrical Conductivity
EFR	East Flowing Rivers
ERM	Extension, Renovation and Modernization
ETP	Effluent Treatment Plant
EW	Exploratory Well
FAO	Food and Agriculture Organization
FC	Flood Control

FF	Flood Forecasting
FMP	Flood Management Programme
FRL	Full Reservoir Level
G	Gauge
GCA	Gross Command Area
GD	Gauge and Discharge
GDQ	Gauge, Discharge and Water Quality
GDS	Gauge, Discharge and Sediment
GDSQ	Gauge, Discharge, Sediment and Water Quality
GFCC	Ganga Flood Control Commission
GIS	Geographical Information System
GOI	Government of India
GPI	Grossly Polluting Industries
GSC	Gross Storage Capacity
ha	Hectare
HE	Hydro-Electric
HFL	Highest Flood Level
HO	Hydrological Observation
hrs	Hours
I&CAD	Irrigation and Command Area Development
IBO	Indus Basin Organization
IBTL	Inter-Basin Transfer Link
IBWT	Inter-Basin Water Transfer
ICAR	Indian Council of Agricultural Research
ICPO	Irrigation-Cum-Power Outlet
IM	Moisture Index
IMD	Indian Meteorological Department
India-WRIS	India-Water Resources Information System
IR	Irrigation
IRS	Indian Remote Sensing
ISRO	Indian Space Research Organization
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
K&GBO	Krishna and Godavari Basin Organization
km	Kilometer
LBC	Left Bank Canal
LGBO	Lower Ganga Basin Organization
LGP	Length of Growing Period
LISS	Linear Imaging Self-scanning Sensor
lps	Litres Per Second

LSC	Live Storage Capacity
LULC	Land Use Land Cover
m	metre
M&ERO	Mahanadi and Eastern Rivers Organization
MAF	Million Acre Feet
MCM	Million Cubic metre
Mcum	Million Cubic metre
MDDL	Minimum Draw Down Level
mg/l	Milligram per Litre
MI	Minor Irrigation
MLD	Million Liters per Day
mm	Millimeters
MMIR	Major and Medium Irrigation
MOSDAC	Meteorological & Oceanographic Satellite Data Archival Centre
MoU	Memorandum of Understanding
MoWR	Ministry of Water Resources
MPN	Most Probable Number
MSL	Mean Sea Level
MU	Million Units
MW	Mega Watt
N&TBO	Narmada and Tapi Basin Organization
NBO	Narmada Basin Organization
NBSS & LUP	National Bureau of Soil Survey & Land Use Planning
NEEPCO	North Eastern Electric Power Corporation Limited
NEIC	North Eastern Investigation Circle
NF	No Flow
NGRBA	National Ganga River Basin Authority
NHPC	National Hydro Power Corporation Limited
NRLD	National Register of Large Dam
NRSC	National Remote Sensing Centre
NW	National Waterway
NWDA	National Water Development Authority
NWDT	Narmada Water Disputes Tribunal
NWMP	Northern Water Monitoring Programme
NWP	National Water Policy
OW	Observatory Well
P	Precipitation
PET	Potential Evapotranspiration
PH	Power House
pH	puissance de Hydrogen

ppm	parts per million
PS	Pisciculture
PW	Peizometre Well
Q	Water Quality
R&R	Rehabilitation and Resettlement
RBC	Right Bank Canal
RF	Rainfall
RRR	Repair, Renovation and Restoration
RRSC	Regional Remote Sensing Centre
RSC	Residual Sodium Carbonate
S	Sediment
SAC	Standing Advisory Committee
SAR	Sodium Absorption Ratio
SD	Sub Division
SMCS	Soil Moisture Control Section
SOI	Survey of India
Sq. km	Square Kilometers
SRTM	Shuttle Radar Topographic Mission
TAC	Technical Advisory Committee
TBO	Tapi Basin Organization
TC	Total Coliform
TDS	Total Dissolved Solids
Th ha	Thousand Hectare
THDC	Tehri Hydro Development Corporation
TW	Tube well
UGBO	Upper Ganga Basin Organization
UIP	Ultimate Irrigation Potential
UJVNL	Uttarkhand Jal Vidyut Nigam Limited
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPJVNL	Uttar Pradesh Jal Vidyut Nigam Limited
UT	Union Territory
WB	Water Body
WFR	West Flowing Rivers
WMO	World Meteorological Organization
WS	Water Supply
YBO	Yamuna Basin Organization

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Authors

ISRO Officials

Dr. V.K. Dadhwal
Director
National Remote Sensing Centre (NRSC)
ISRO, Department of Space, Govt. of India
Balanagar, Hyderabad

Dr. J.R. Sharma
Project Director, India-WRIS Project &
Chief General Manager
Regional Remote Sensing Centres - NRSC/ ISRO
DOS Branch Secretariat, Loknayak Bhawan
New Delhi

Dr. B.K. Bhadra
Scientist/Engineer 'SF'
Regional Remote Sensing Centre-West
NRSC, ISRO, Jodhpur

Mr. Rahul Sharma
Research Scientist
Regional Remote Sensing Centre-West
NRSC, ISRO, Jodhpur

Ms. Ila Agnihotri
Research Scientist
Regional Remote Sensing Centre-West
NRSC, ISRO, Jodhpur

Mr. Jai Prakash Jyani
Research Scientist
Regional Remote Sensing Centre-West
NRSC, ISRO, Jodhpur

CWC Officials

Er. A. Mahendran
Member (WP & P)
Central Water Commission
New Delhi

Er. W.M. Tembhurney
Chief Engineer (EMO)
Central Water Commission
New Delhi

Er R. K. Jain
Chief Engineer (BPMO)
Central Water Commission
New Delhi

Er. Yogesh Paithankar
Director
Remote Sensing Directorate
Central Water Commission, New Delhi

Er. Alok Paul Kalsi
Deputy Director
Remote Sensing Directorate
Central Water Commission, New Delhi

India-WRIS Project Team

ISRO Officials

Project Director	Dr. J R Sharma
Convener (S/W)	Sh. P G Diwakar
Quality Assurance Team	Sh. V M Bothale, Sh. M V Ravikumar, Dr. S S Rao, Dr. S N Das, Sh. D S P Rao, Ms. A Vijaya Banu, Sh. Chandrasekaran, Sh. D J Chutia
Convener (Database)	Dr. A Jeyaram
Quality Assurance Team	Dr. S Sudhakar, Sh. Uday Raj, Dr. M Kudrat, Ms. Rajashree V Bothale, Dr. D Dutta, Dr. G Ravishankar, Sh. S Pathak, Dr. K K Sarma
Project Coordinators	Sh. Shantanu B., Sh.Uday Raj, Dr. A T Jeyaseelan
Project Managers	Dr. A K Bera, Dr. B K Bhadra, Sh. S Pathak, Dr. Rakesh Paliwal

CWC Officials

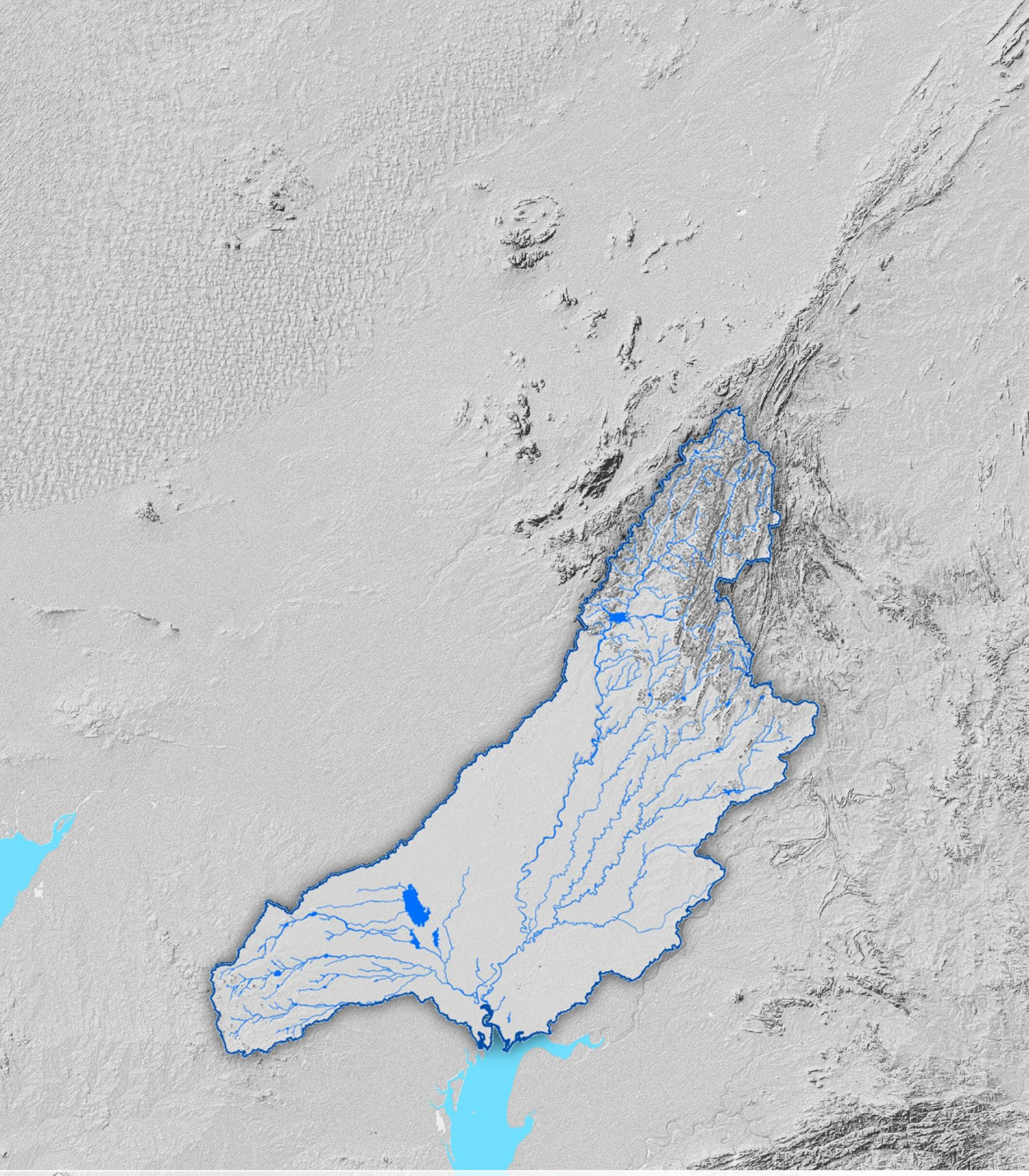
Project In-charge
Er. Yogesh Paithankar, Director

Dy. Project In-charge
Er. Alok Paul Kalsi, Dy. Director
Er. Prashant Kumar Gupta, Dy. Director

Technical Guidance
Er. C K Agarwal, Chief Engineer (B & BBO)
Er. W M Tembhurney, Chief Engineer EMO
Er R.K. Jain, Chief Engineer (BPMO)

Groups and Work Components	Project Leads & Project Scientists at Lead Centre	Research Scientists at Lead Centre	DPDs & Project Scientists	Team
S/W Design, Architecture, Integration, Data Security, Web Hosting & Website	**Sh. Gaurav Kumar** Sh. K S Srinivasan Sh. Hansraj Meena	Ms. Suman Gurjar Ms. Pragya Chaturvedi Ms. Shilpa Taneja Ms. S V Pravalika Ms. Divya Mishra Ms. Jyotsana Chuchra Mr. Samuel Lourdraj C Mr. Rahul Sharma Mr. Piyush Dubey Mr. V Srinivasa Reddy Ms. Chitra S Pai Ms. Manasa Devi B Mr. Mohamed Ali S Ms. Hemlata Gehlot Mr. Amit Kumar Mr. Devdatta Tengshe Mr. Jai Prakash Jyani Mr. Munish Gorsi Ms. Deepika Acharaya Ms. Pratima Tak Mr. Niteen K Bankar Ms. Himani Singh Ms. Sneha Ms. Kamini Yadav Mr. Goutam Bhati Mr. Debhasish Bhakta Mr. Nitin Chauhan Ms. Ila Agnihotri Mr. Vishal Singh Ms. Vineeta Sharma Dr. N Vyjayanthi Dr. Shirsath Paresh B Mr. Sanjay Kumar Ms. Rashmi Rekha Dutta Mr. Brij Kishor Jashal	**Sh. Vinod M Bothale** Sh. Shantanu B Sh. K Nagajyothi Sh. S S Rajashekhar Sh. Harish Karnatak Sh. D Giribabu Dr. A V Suresh Babu Sh. E Sivasankar	Er. Navin Kumar, Director Er. S N Abraham, Director Er. R Azhagesan, Director Er. Ashish Banerjee, Director Er. Rajiv Kumar, Director Er. Piyush Ranjan, Executive Engineer Er. Pankaj Sharma, Dy. Director Er. Amarjit Singh, Dy. Director Er. S K Chaturvedi, Dy. Director Er. Y S Varshney, Executive Engineer Er. Manoj Paunikar, Executive Engineer Er. Amitabh Prabhakar, Executive Engineer Er. Vishal Garg, Assistant Director Er. M Sahabdeen, Assistant Director Er. Ashish Awasthi Assistant Director Er. R. Bhaskaran, Assistant Director
Database Organization & Geo-database Standards	**Dr. A K Bera** Dr. Rakesh Paliwal		**Dr. M C Gupta** **Dr. S N Das** Dr. S S Rao Sh. K Abdul Hakeem	
Legacy Data ISRO Projects	**Dr. Rakesh Paliwal** Sh. Ashish Kumar Jain		**Dr. V V Rao** Dr. G Ravishankar Dr. A V Suresh Babu Sh. B Simhadhari Rao	
Watershed Atlas & Water Resources Projects	**Dr. A K Bera** Dr. Rakesh Paliwal Er. Sagar S Salunkhe		**Ms. Rajashree V B** Dr. G Sreenivasan Dr. S Ravindranath Dr. K H V Durga Rao	
Administrative & Thematic Layers	**Dr. B K Bhadra** Dr. Rakesh Paliwal Sh. S Pathak Sh. Sushilkumar B Rehpade Sh. Amanpreet Singh		**Dr. D Dutta** Dr. V M Choudhary Sh. P V Raju Sh. P Satyanarayana	
Environmental Data	**Dr. S Rama Subramoniam** Dr. Manoj Joseph		**Dr. S N Das** Sh. John Mathew Sh. M Shanker Sh. B Simhadhari Rao	
Capacity Building, Modelling, Value Addition & Report	**Sh. S Pathak**		**Dr. P Manavalan** Sh. Pramod Kumar Sh. P V Raju Dr. K H V Durga Rao	

Lead Centre: Regional Remote Sensing Centre - West, NRSC/ISRO, Jodhpur



इंडिया-वारिस

India-WRIS

A Joint Project of CWC and ISRO

देश में जल संसाधन आँकड़ों का जनन व वेब सामर्थ्य
सूचना प्रणाली का क्रियान्वयन

Generation of Database and Implementation of Web Enabled Water Resources Information System (India-WRIS) in the Country